FINAL REPORT
250 kV ELECTRON GUN

JANUARY 1986

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Two high-voltage, high-power Pierce-type electron guns were designed and developed for use at the NRL high-power ubitron laboratory. The design of the high-voltage and vacuum housings of the guns incorporates design features utilized in the SLAC XK-5 klystron gun. Detail design data and beam trajectories are presented. Beam analyzer and high voltage tests are discussed. Assembly and detail drawings are included.

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1.0 INTRODUCTION

1.1 PURPOSE

The purpose of this program was to develop a high-voltage, high-power Pierce-type electron gun to be used for experiments at the NRL high-power ubitron laboratory. These experiments are intended for high-power, high-quality electron-beam generation, beam diagnostics, and high-power microwave generation techniques.

1.2 SCOPE

In accordance with Contract No. N00014-85-C-2059 two electron guns were fabricated, pretested and delivered to NRL. The high-voltage and vacuum housings of the guns were consistent with the design utilized in the Stanford Linear Accelerator Center (SLAC) XK-5 klystron gun. This 12-month development program covers the period from December 1984 through December 1985.

The report describes details of beam optics calculations, performance characteristics, pretest results, and includes assembly and detail drawings along with a material list.

2.0 CALCULATIONS AND COMPUTED RESULTS

2.1 DIODE CHARACTERISTICS AND ELECTRON TRAJECTORIES

The process of arriving at optimum electron beam trajectories involves an iterative computational procedure and computer graphics plotting. Repetitive testing in the Varian computer controlled beam analyzer, to confirm the desired results, is limited to lower voltages (20 kV to 25 kV). Finalized electrostatic beam trajectories are illustrated in Figure 1 and Figure 2 for 20 kV and 250 kV respectively.

2.2 MAGNETIC FIELD

In the case of a confined-flow focusing system the magnetic field at the cathode can be determined approximately from the following expression:

$$B_c = \frac{(B_o)\ (\alpha)}{(r_c/r_o)^2} \text{ gauss}$$

where:
- Bc = Magnetic Field at Cathode
- B_o = Main Field
- r_c = Radius of Cathode
- r_o = Radius of Beam
- α = Cathode Flux Parameter

The mathematical expression for calculating is as follows:

$$\alpha = \sqrt{1 - \left(\frac{B_{br}}{B_o}\right)^2}$$

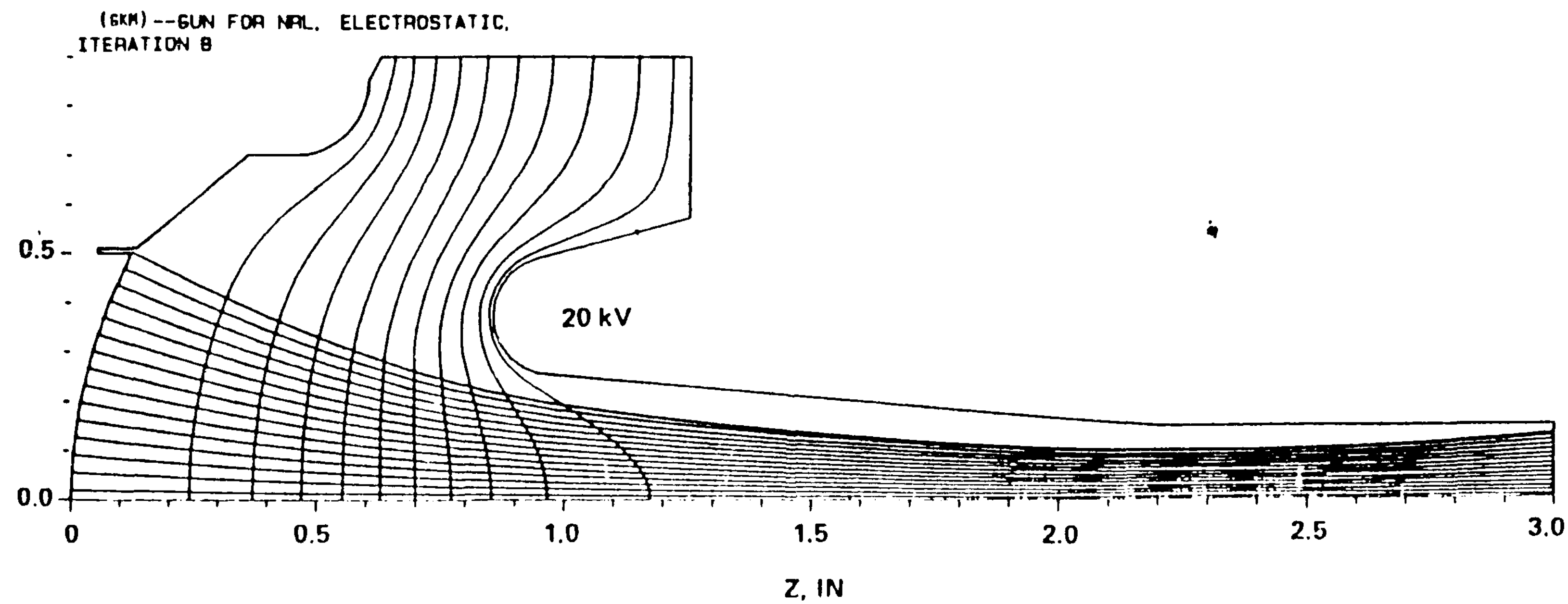


FIGURE 1. NONRELATIVISTIC BEAM TRAJECTORIES (20 kV)

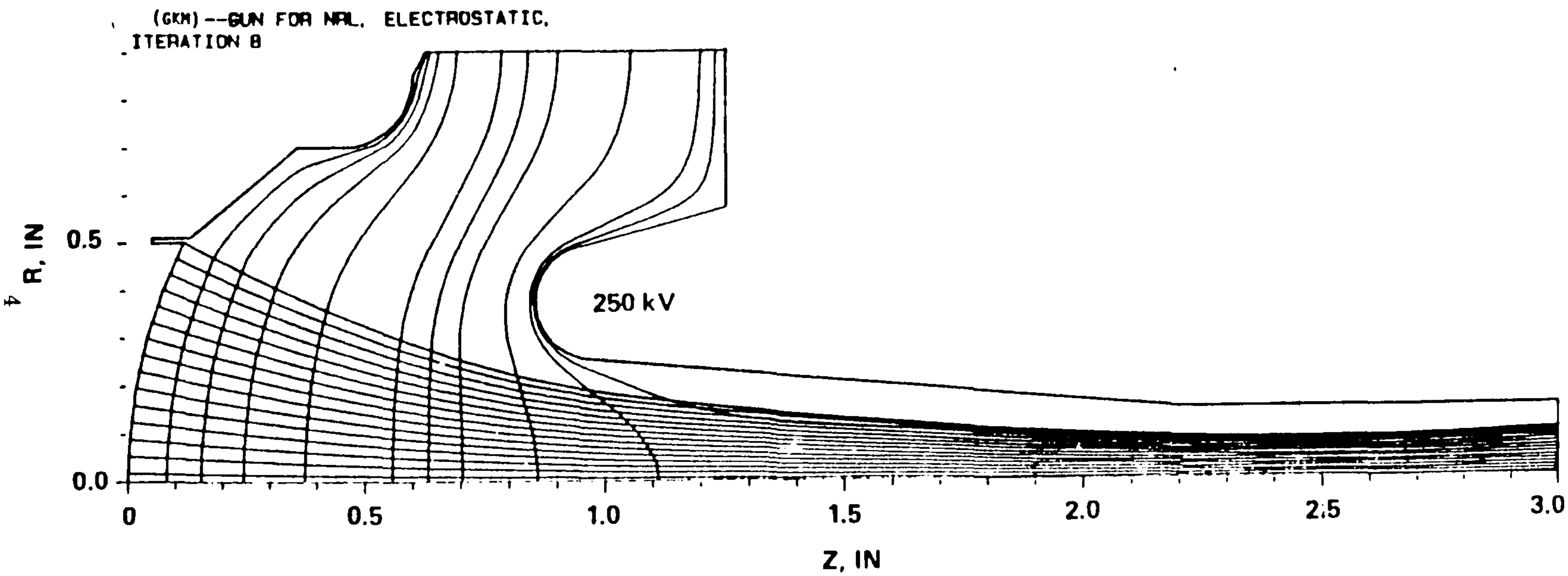


FIGURE 2. RELATIVISTIC BEAM TRAJECTORIES (250 kV)

where: B_{br} is the Brillouin field value and is equal to

$$B_{br} = \frac{463.5 \ (V) \ (k)}{d} \qquad \text{(For Low Beam Voltages)}$$

$$= \left(\frac{468}{d}\right) \cdot \frac{\mu^{1/2}}{\left[\dfrac{\left(1 + \dfrac{V_o}{2 \times 510.98}\right)^{1/2} \ 1/2}{\dfrac{V_o}{510.98}}\right]} \text{Field} \qquad \text{Relativistically Corrected } B_{BR}$$

where: μ = Microperveance

V_o = Beam Voltage in kV

where: d = Beam Diameter (inches)

V = Beam Voltage

k = Perveance

The design magnetic field is calculated from these expressions and is plotted in Figure 3. (Relativistic)

2.3 COMPUTER GUN OPTICS DESIGN

With the aid of the Varian computer gun design programs, several designs were generated and analyzed. The gun electrode geometries were optimized in order to achieve the desired beam characteristics and voltage gradients around the focus electrode anode areas. Aside from determining the required perveance, convergence and voltage gradients, special attention was given to produce an extremely laminar beam in order to obtain the minimum axial velocity spread. In the final design, the velocity spread was computed to be 0.295%. Details of computer calculations were described in detail in previous reports.

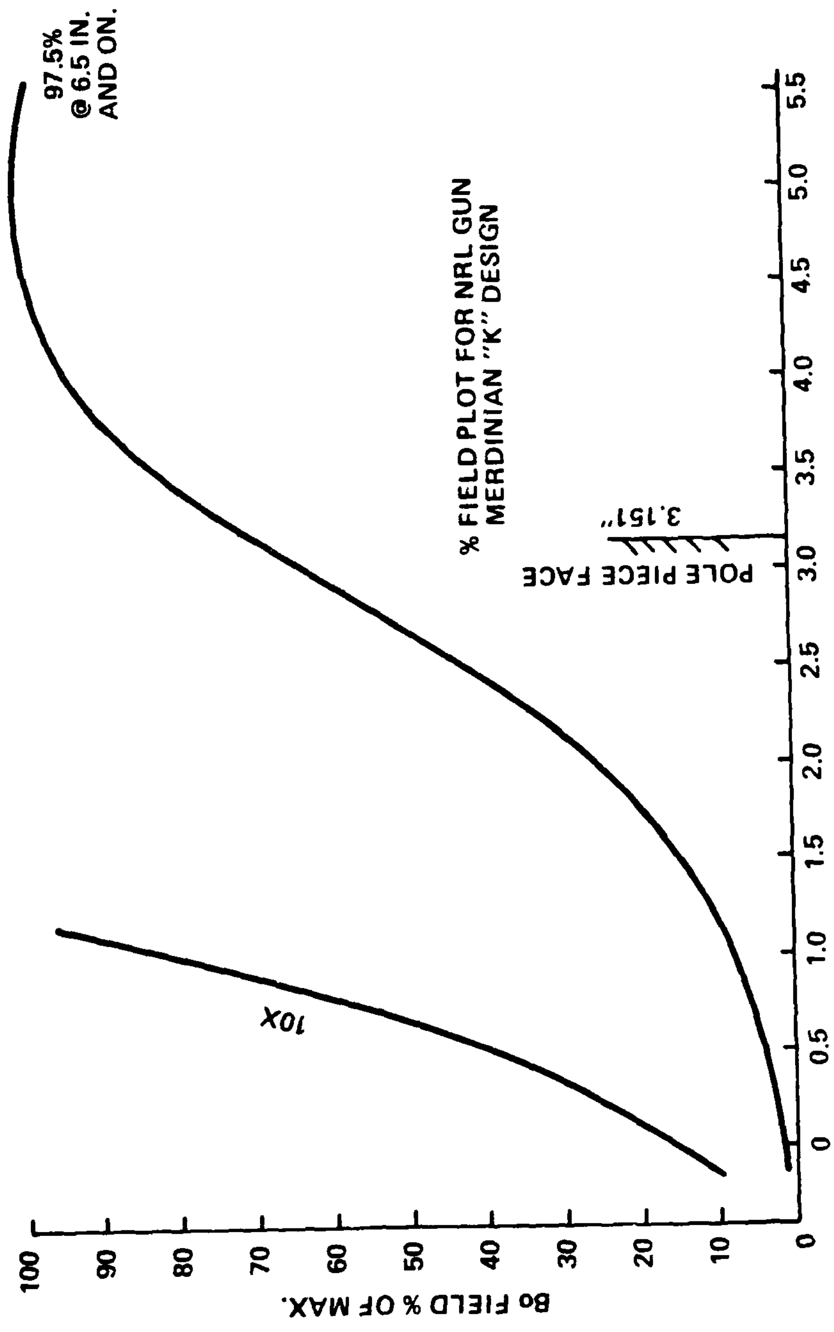


FIGURE 3. % MAGNETIC FIELD vs DISTANCE FROM CATHODE

In order to test the gun in the beam analyzer the tests can only be made at maximum voltage of 20 kV. The magnetic field was correspondingly adjusted.

3.0 DESIGN METHODOLOGY

The design and development of this electron gun followed a procedure which defines a certain sequence of events as described below:

1. A detailed computer analysis of the Pierce-type diode gun was performed at two beam voltages of 20 kV and 250 kV.

2. The beam trajectories in a confined-flow magnetic focusing field were calculated and plotted by the computer for 20 kV and 250 kV as illustrated in Figure 4 and Figure 5 respectively.

3. In order to ensure the integrity of the design at high-voltage operation, a computer plot of the voltage gradient in vacuum was generated as shown in Figure 6.

4. The electrostatic beam optics were then evaluated in a computer-controlled beam analyzer and the configuration refined for optimum performance.

5. Subsequently, the electron gun was placed in a confined-flow magnetic focusing field and retested. Reiterative modifications to the magnetic focusing field were introduced until satisfactory results were obtained.

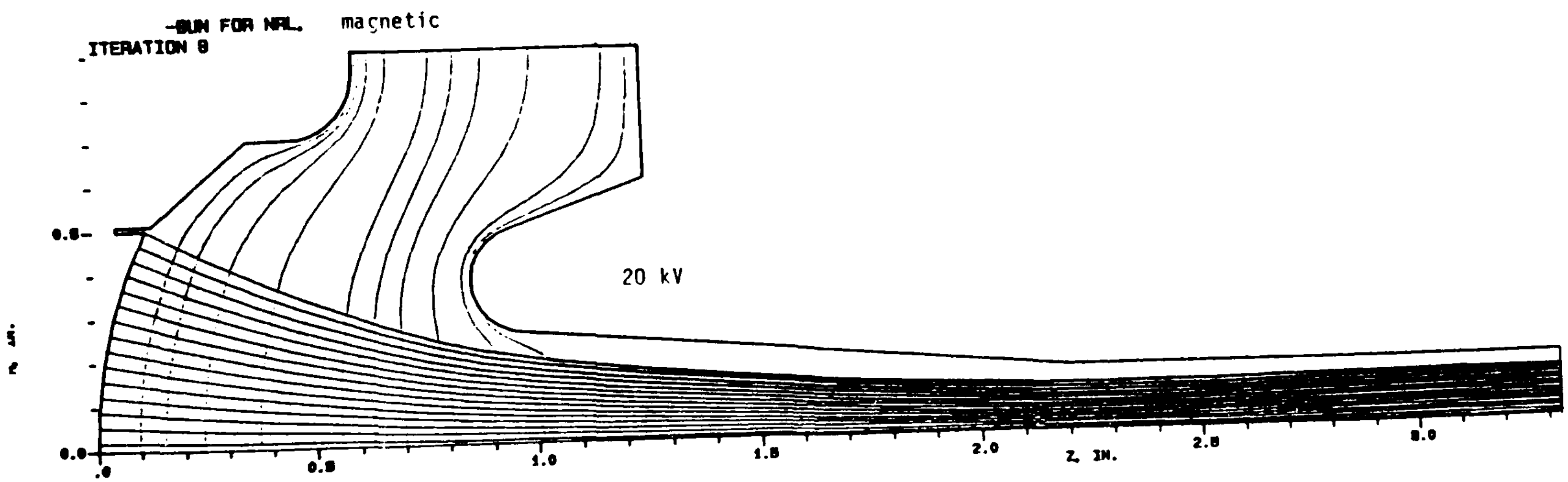


FIGURE 4. BEAM TRAJECTORIES IN CONFINED-FLOW MAGNETIC FOCUSING FIELD (20 kV)

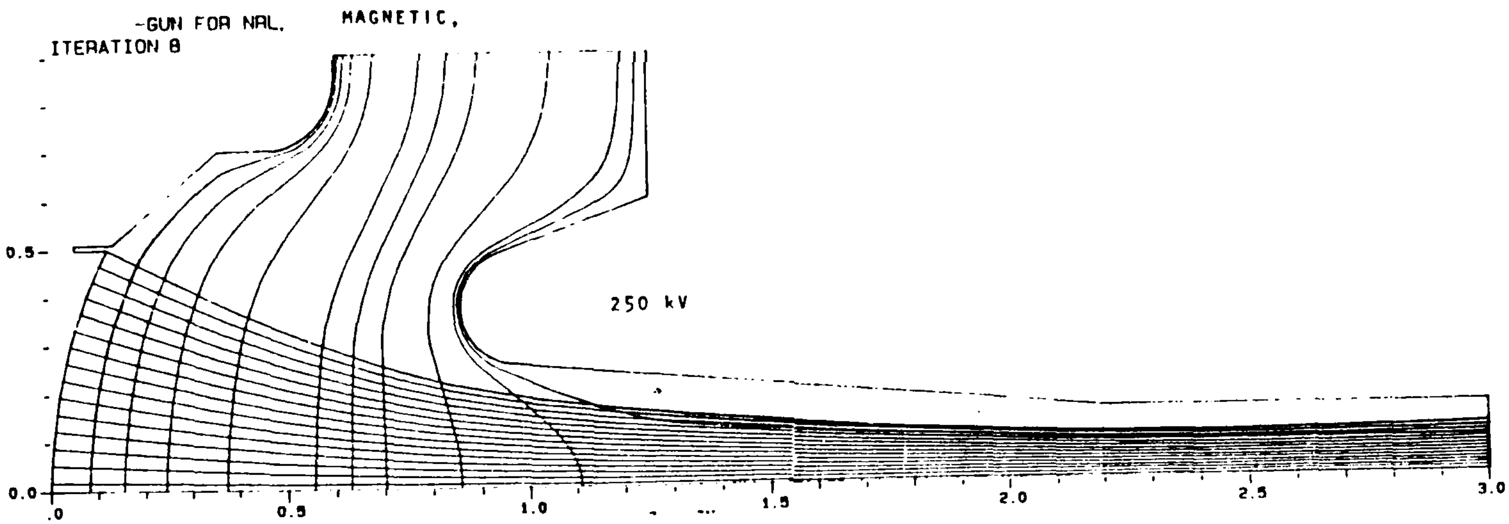


FIGURE 5. BEAM TRAJECTORIES IN CONFINED-FLOW MAGNETIC FOCUSING FIELD (250 kV)

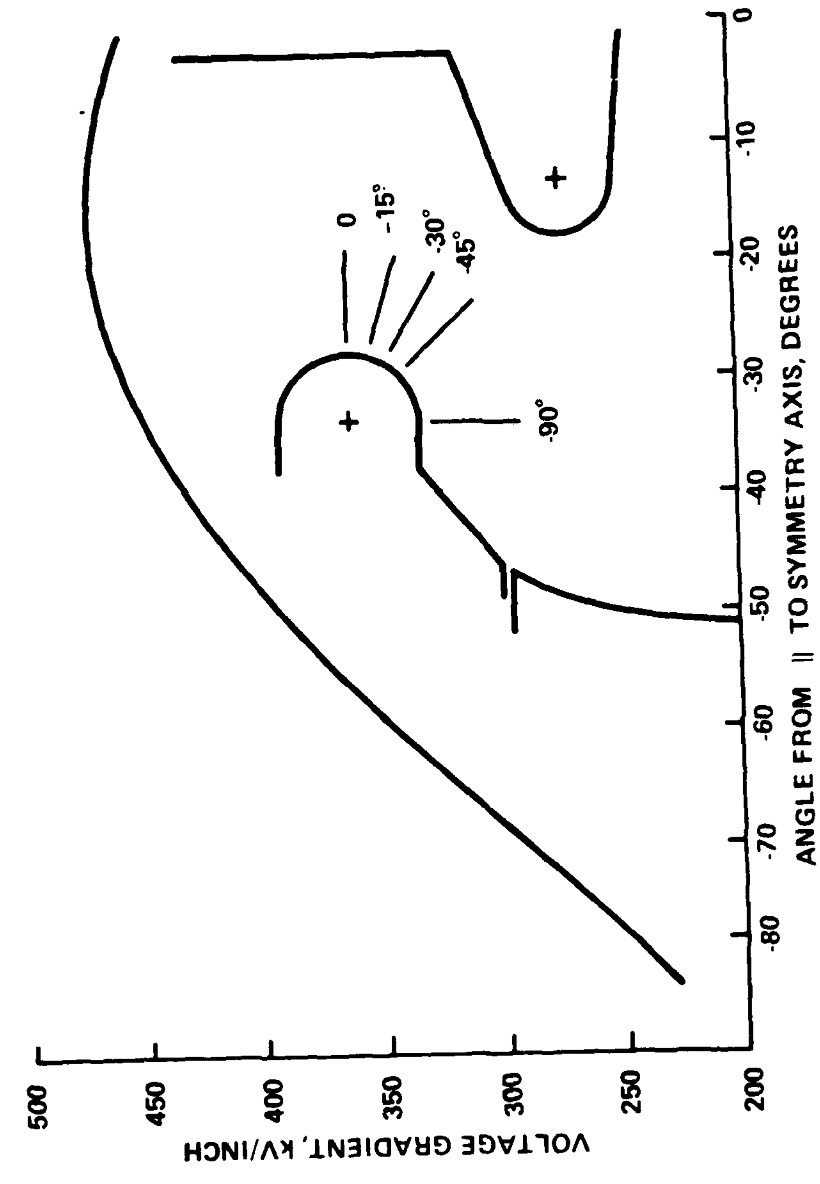


FIGURE 6. VOLTAGE GRADIENT vs FOCUS ELECTRON ANGLE

4.0 ELECTRON GUN SPECIFICATIONS

The finalized electron gun specifications as per Revision A dated 13 December 1984 are summarized below:

4.1	Operating Voltage (cathode pulse)	250 kV
4.2	Cathode Current	100 Amps
4.3	Cathode Heater Voltage (Nom.) (AC)	8.5 Volts
4.4	Cathode Heater Current (Nom.)	18.5 Amps
4.5	Pulse Length (Max)	2 μsec
4.6	Repetition Rate (Max)	100 Hz
4.7	Beam Radius (in 2.5 kG Magnetic Field)	< 0.4 cm
4.8	Beam Centroid Offset (in 2.5 kG magnetic field)	<0.005 cm
4.9	Beam Axial Velocity Spread (biased standard deviation)	<0.4 % with a goal to 0.1% (≈ 8.5% beam ripple)
4.10	Beam Ripple (measured)	<20%
4.11	Concentricity of Cathode and Anode	±0.004 inch
4.12	Angular Deviation (tilt) of Cathode and Anode Relative to Gun Axis (Max)	0.005 radius
4.13	Lifetime (Min)	5000 hrs
4.14	Capacitance (Max)	150 pF
4.15	Gun Connection to Tube (exit drift tube dia to be determined)	2-1/8" dia. Conflat® Flange
4.16	Gun Housing Dimensions	<SLAC XK-5 dimensions

5.0 ASSEMBLY DRAWINGS AND MATERIAL LIST

The electron gun is constructed from three major subassemblies as illustrated in Figure 7.

- High-Voltage Seal (Drawing Items 1 and 3)
- Cathode Assembly (Drawing Item 2)
- Iron Housing and Anode Assembly (Drawing Items 5 and 6)

The high-voltage seal and vacuum housing configuration is consistent with the design utilized in the SLAC XK-5 klystron gun. Assembly and detail drawings of the gun with a parts and material list are given in Appendix A. Cathode assembly is centered in the high-voltage seal assembly within 0.001 in all directions and secured to the base. (Heliarc area at point -3.626 and its associated dimensions are used for centering.)

Iron housing and anode assembly centering also related to the same -3.626 point with its own associated dimensions.

Finally, the iron housing is heliarced to the high-voltage seal assembly.

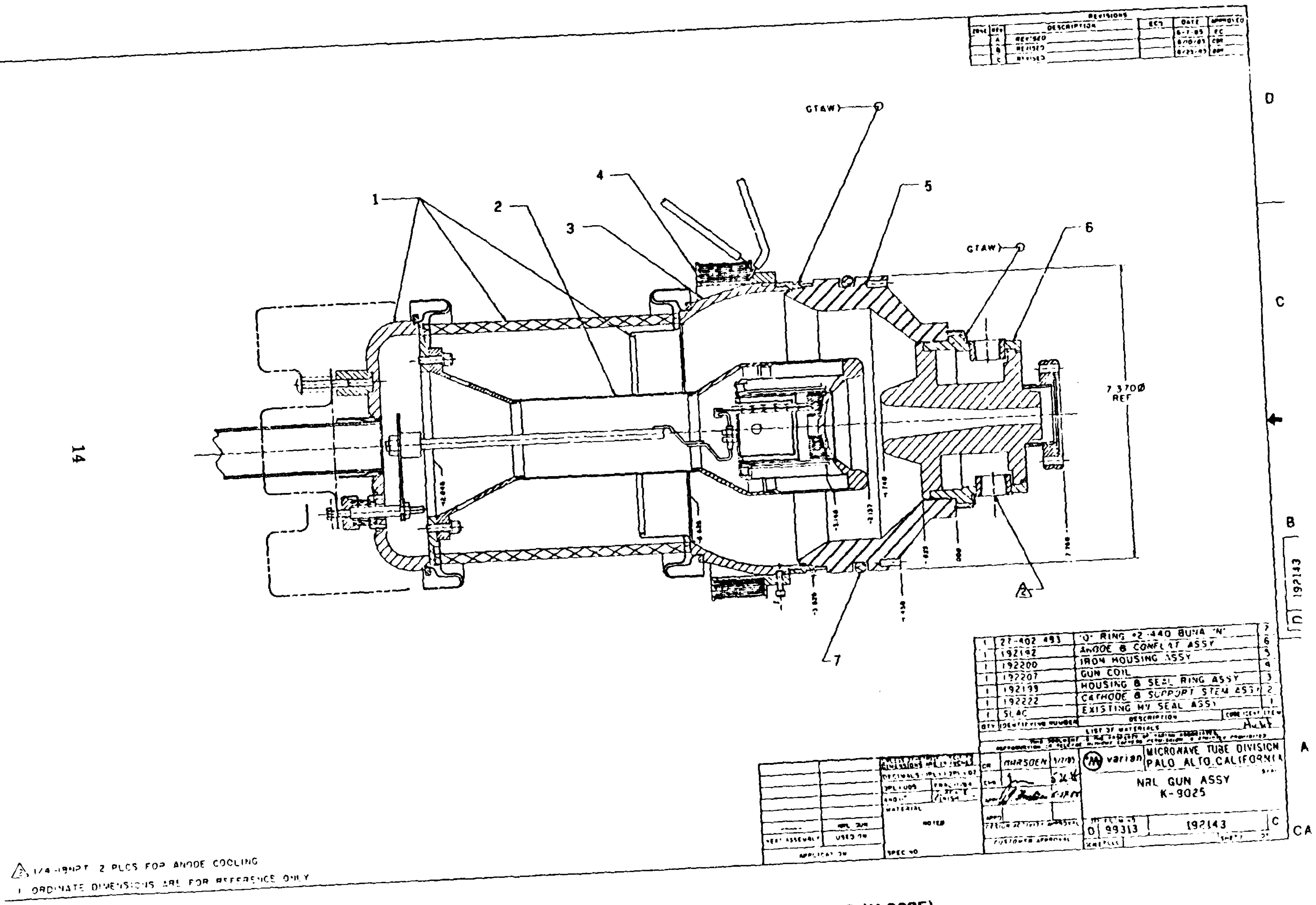


FIGURE 7. ELECTRON GUN ASSEMBLY DRAWING (K-9025)

6.0 TEST RESULTS

6.1 HIGH-VOLTAGE HOLD-OFF TESTS

High-voltage tests were conducted on gun S/N 101. A negative dc voltage was applied to the cathode and gradually raised to 150 kV dc. This level of voltage was held for 10 minutes without arcing and is considered safe for low duty 300 kV two microsecond pulses. See reference in Appendix B titled "Electron Gun Breakdown" by Armand Staprans, Varian Associates, Inc., presented at the 1985 High-Voltage Workshop, February 26, 1985, Monterey, California.

6.2 BEAM ANALYZER TESTS

The first electron gun was tested in the Varian computer-controlled beam analyzer at non-relativistic voltages. The beam tester configuration used in these tests is illustrated in Figure 8. An electrostatic beam profile is shown in Figure 9. The beam diameter, perveance and beam minimum position closely corresponded to the computer predictions.

Magnetic beam analyzer tests have produced an excellent beam with the required perveance and beam diameter. The confined flow beam profiles for the gun are shown in Figure 10. To analyze the quality of the beam optics and magnetic match, the magnetic field was varied from 70 to 110% of the prescribed value with no change in the beam diameter or scalloping. Scalloping was measured to be below 3% in all cases.

A gun coil was used to trim the magnetic field threading the cathode. Varying the field in the gun coil affected the beam diameter with no significant effect on the scalloping. A three-dimensional beam shape in a confined-flow focused magnetic field is illustrated in Figure 11.

6.3 HIGH-VOLTAGE TEST

A short drift tube and isolated collector were fabricated and attached to the gun by means of a 2-3/4 inch Varian Conflat flange. The gun-body-

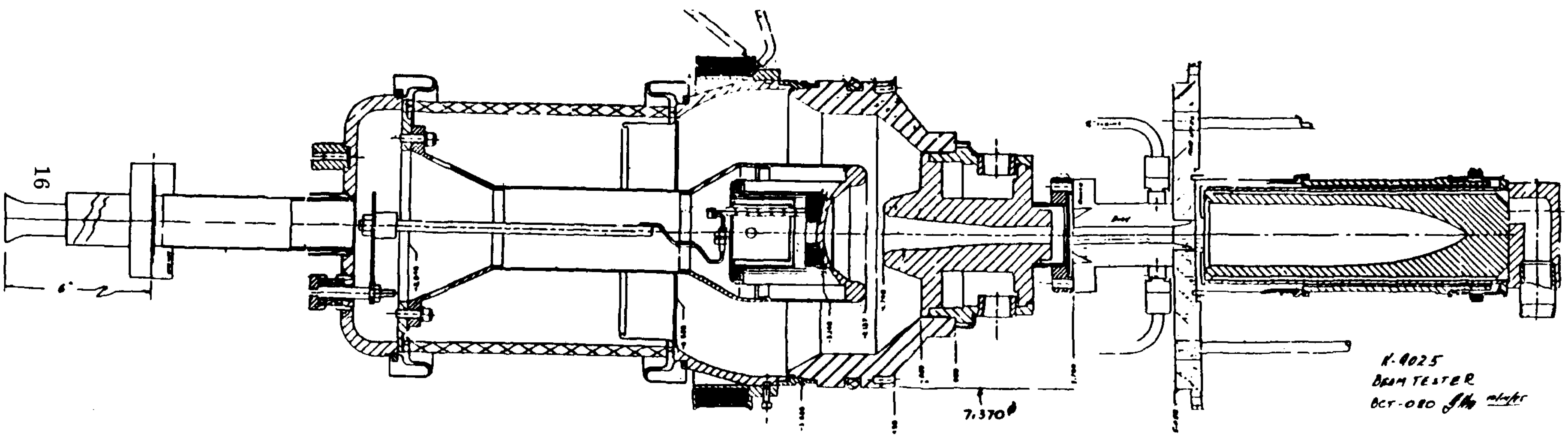


FIGURE 8. BEAM TESTER WITH K-9025 GUN

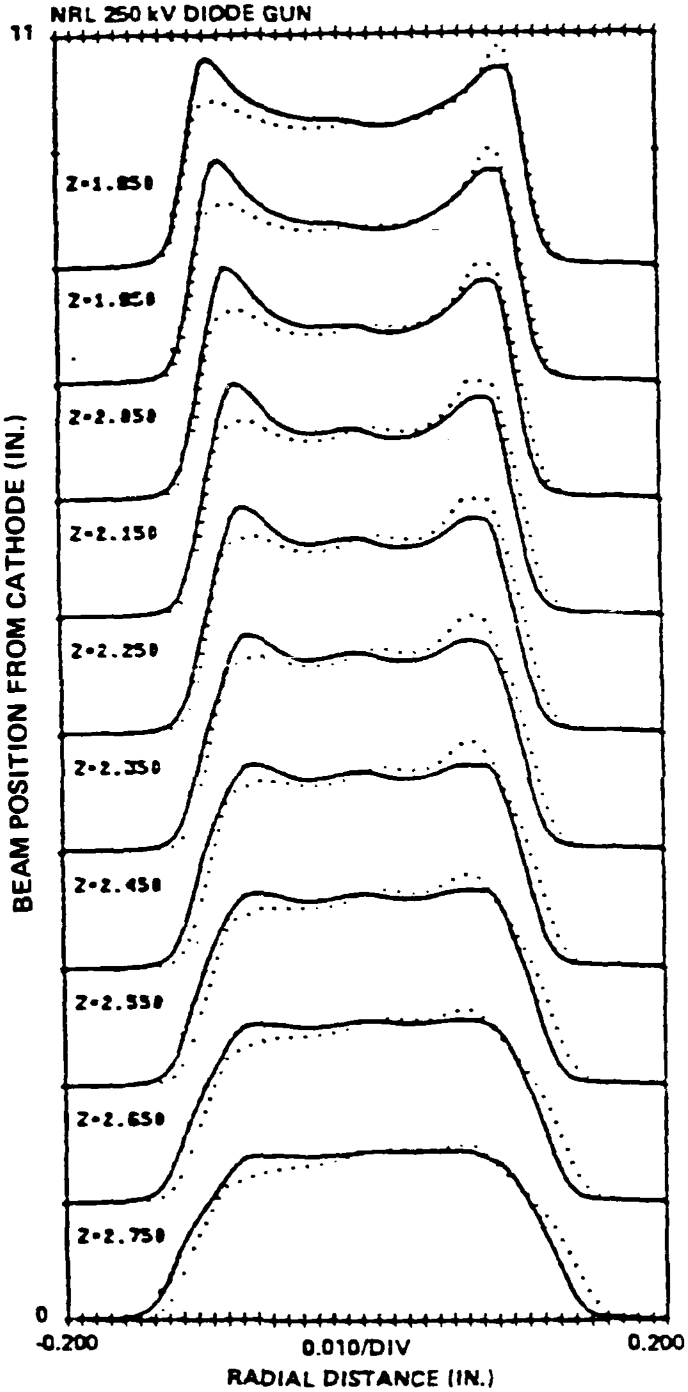


FIGURE 9. ELECTROSTATIC BEAM PROFILES

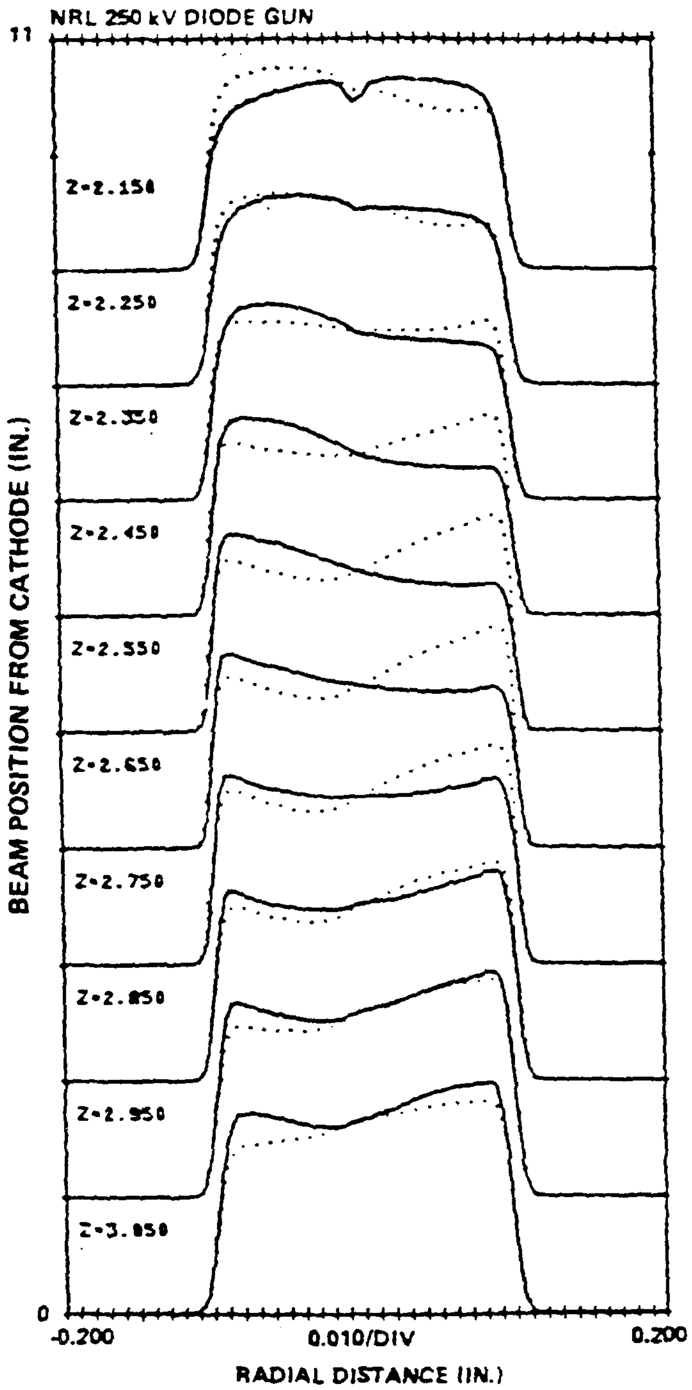


FIGURE 10. CONFINED-FLOW BEAM PROFILES

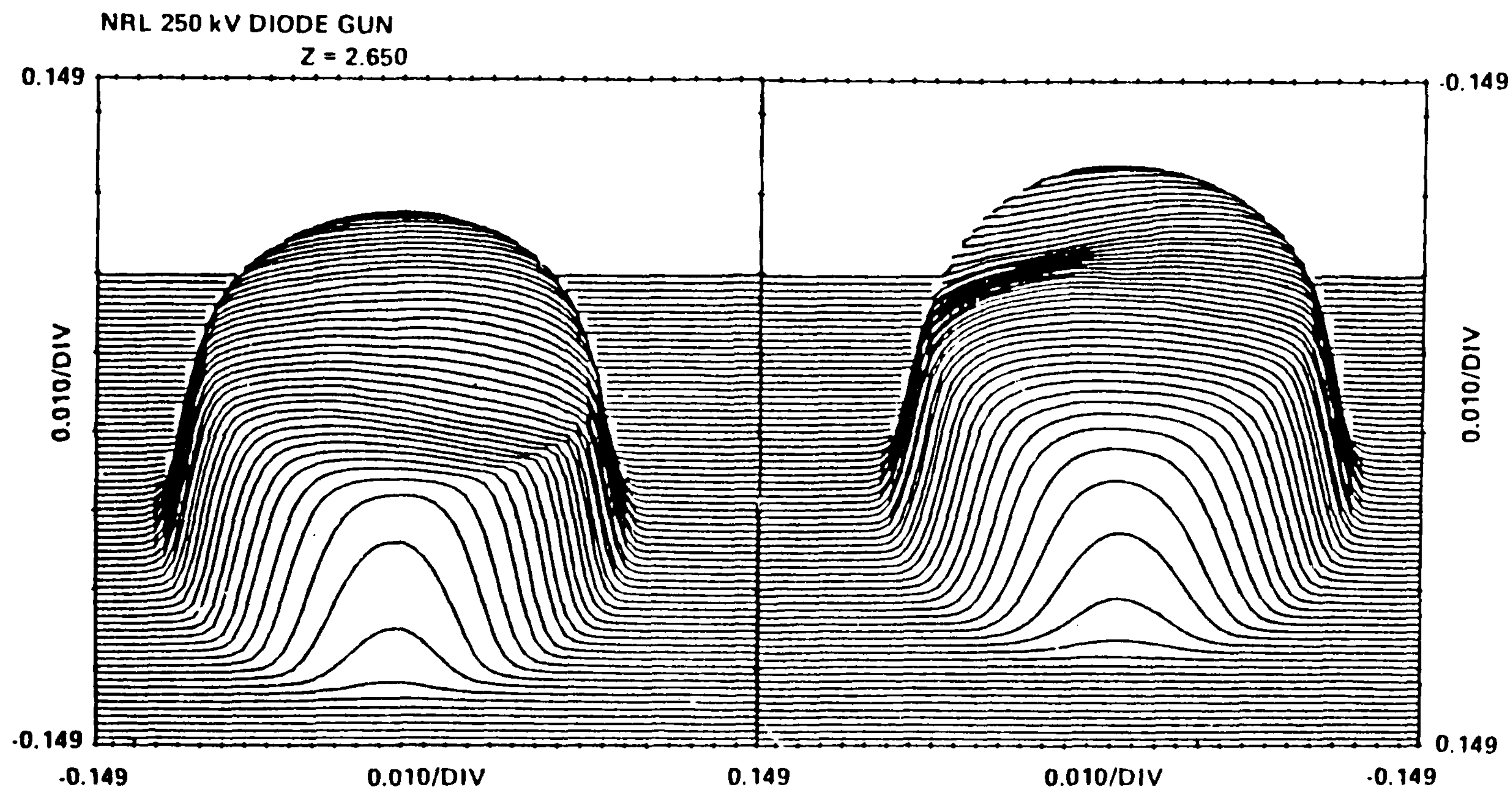


FIGURE 11. 3-D CURRENT DENSITY PROFILES

collector assembly was exhausted, baked out at 450°C, pinched off and tested under oil up to 150 kV dc.

6.4 CONCLUSION

A high-quality, high-voltage gun with excellent beam laminarity has been developed for fast-wave device applications. The beam tester has been fabricated and is ready for test and evaluation. This high-power evaluation will be evaluated at NRL.

APPENDIX A

1. ELECTRON GUN ASSEMBLY DRAWING

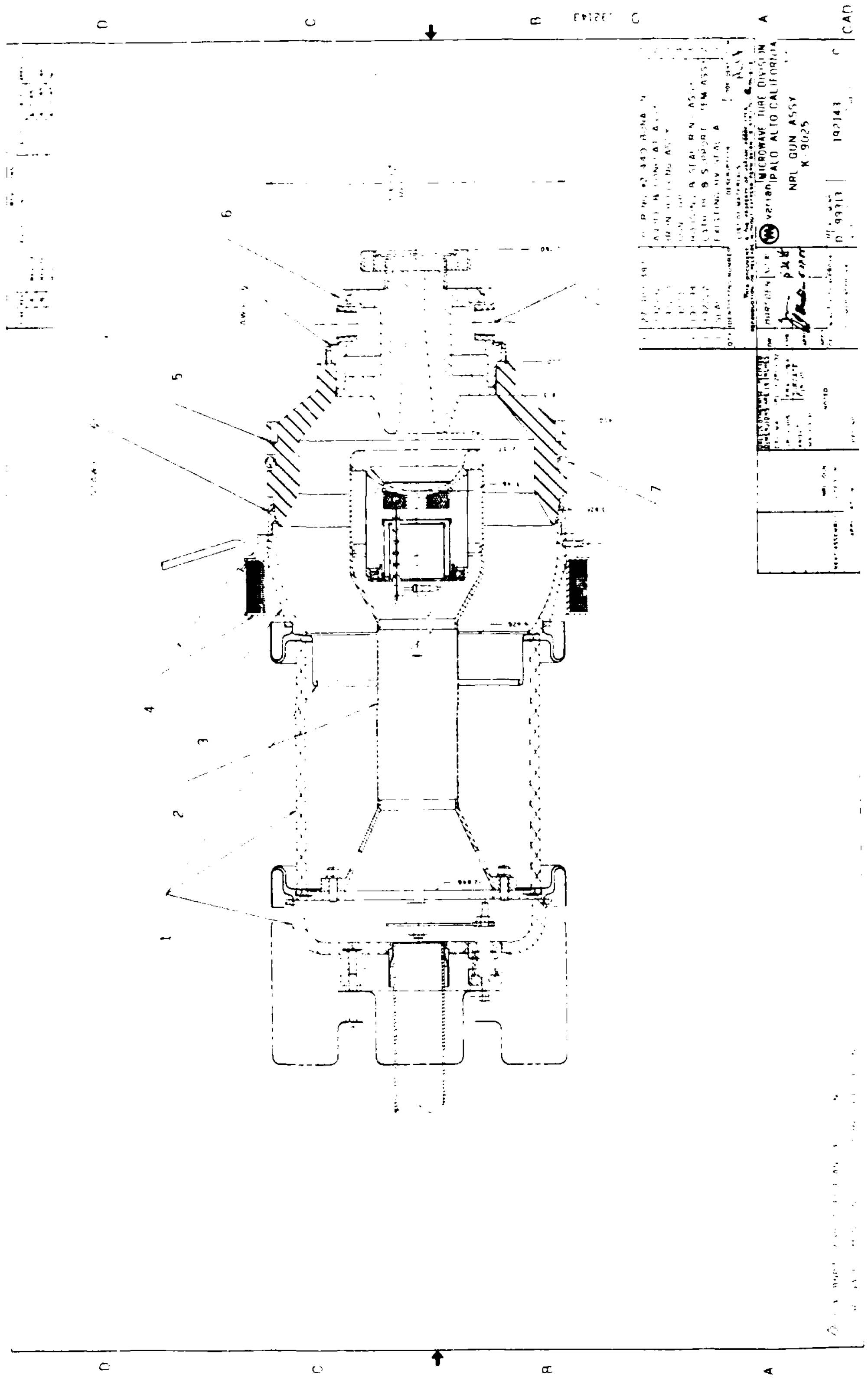
2. DETAIL PARTS DRAWINGS
   (Varian Associates, Inc.)

3. DETAIL PARTS DRAWINGS
   (SLAC)

4. PARTS AND MATERIALS LIST

APPENDIX A-1

ELECTRON GUN ASSEMBLY DRAWING


MICROWAVE TUBE DIVISION
PALO ALTO CALIFORNIA
NRL GUN ASSY
K 9025
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APPENDIX A-2

DETAIL PARTS DRAWINGS
(Varian Associates, Inc.)

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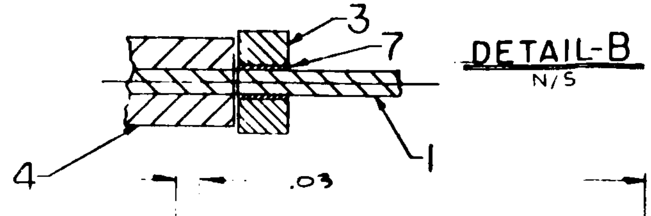

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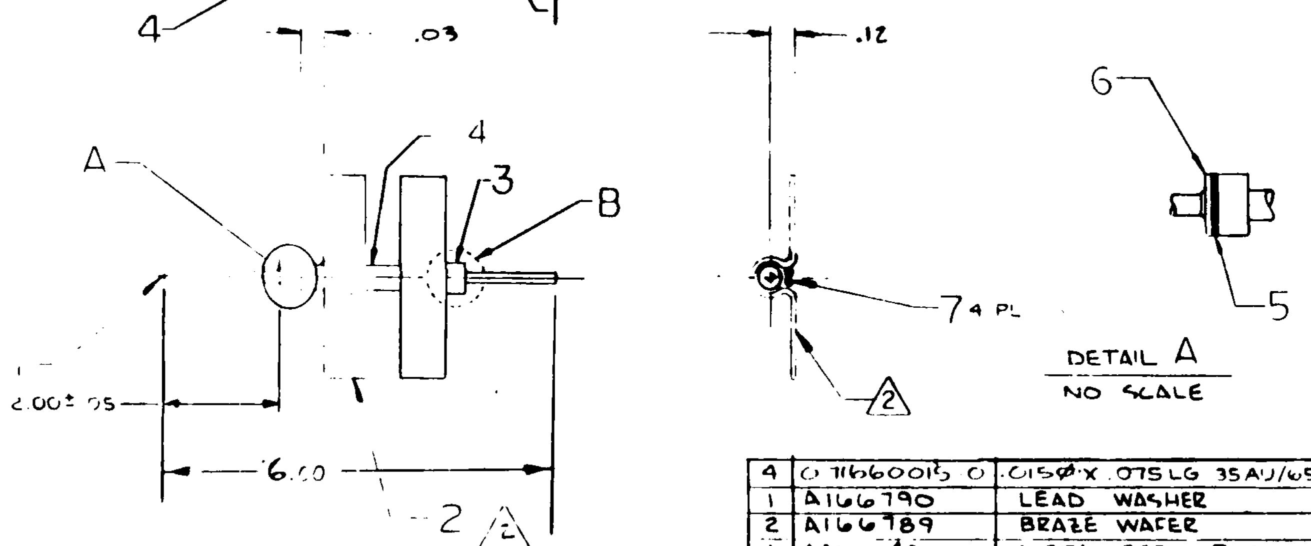

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1	A166486	METALIZED BUSHING		4
1	A142138	STOP LEAD BUSHING		3
2	A091834	LEAD SUPPORT		2
AR	0-24515 006-0	.062 Ø NICKEL BAR /P2-2B		1

LIST OF MATERIALS — AUDIT D

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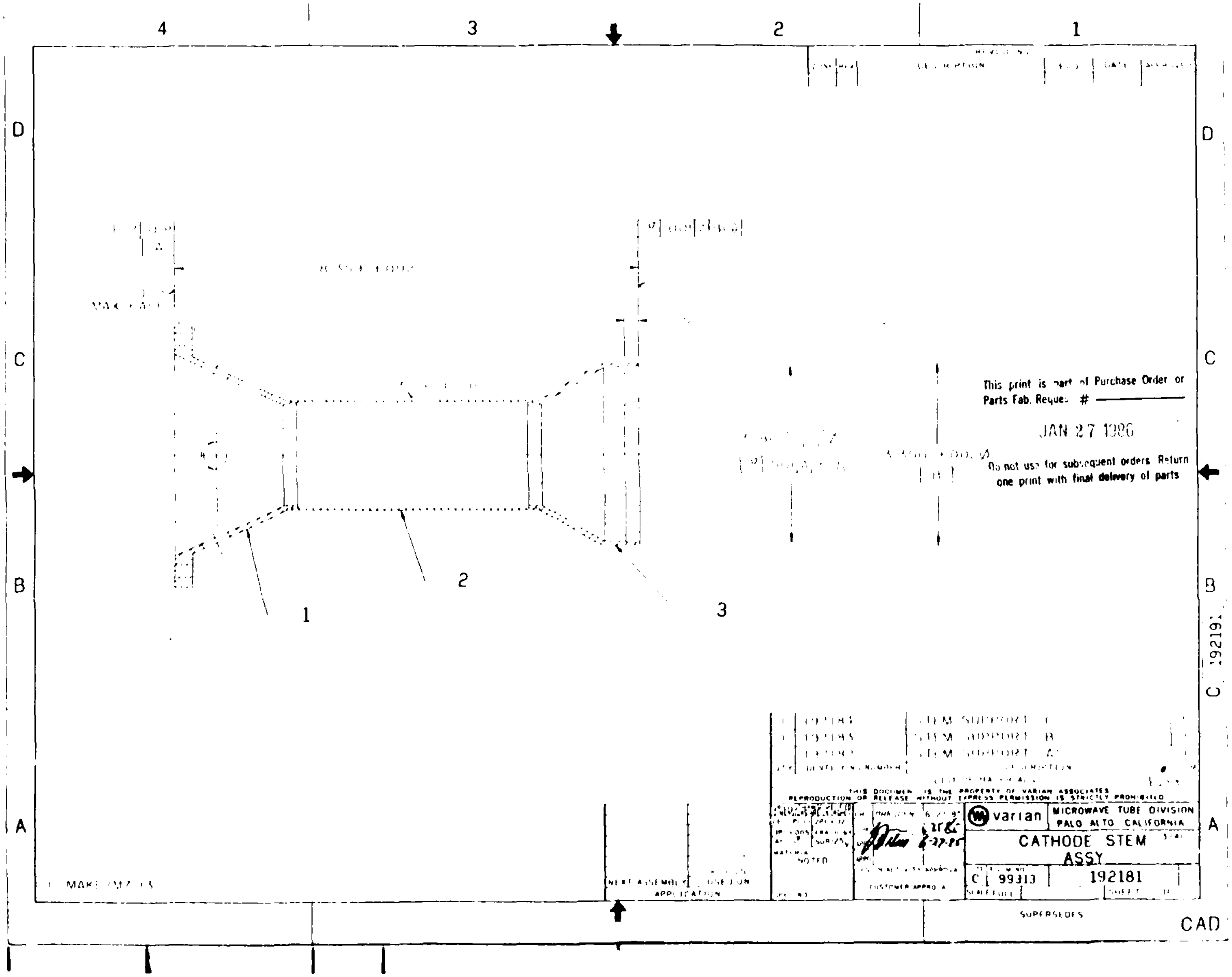

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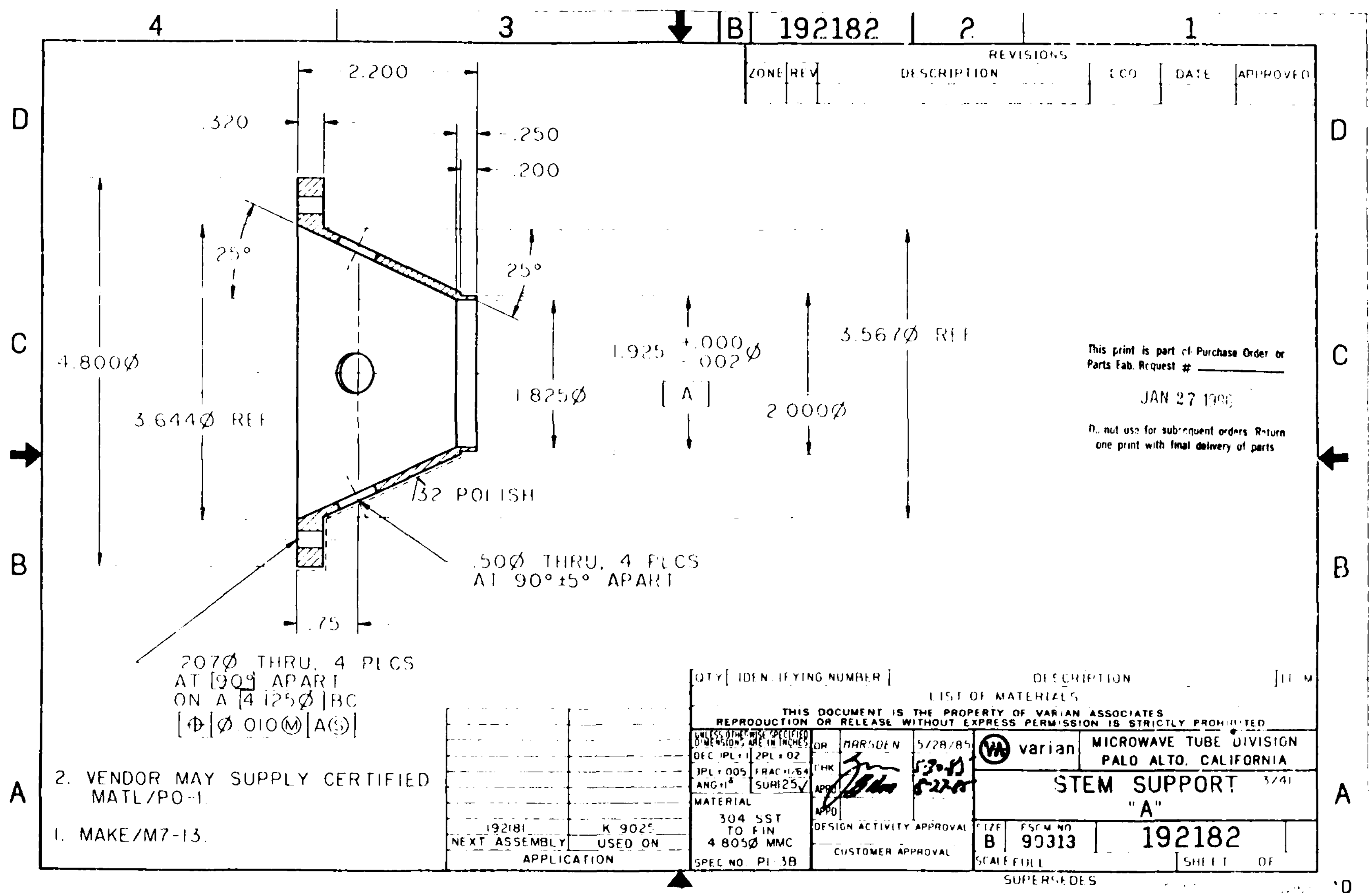
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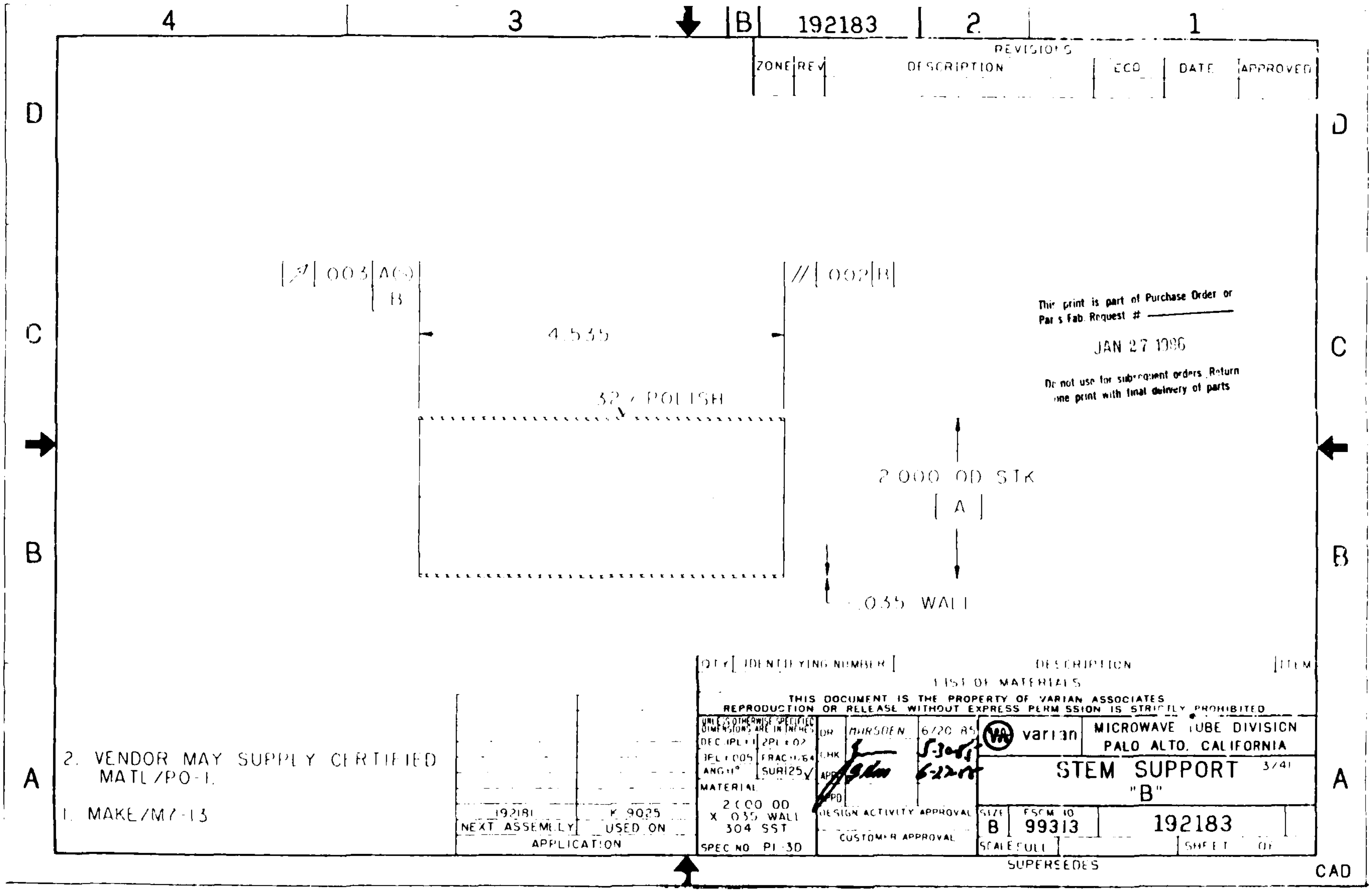
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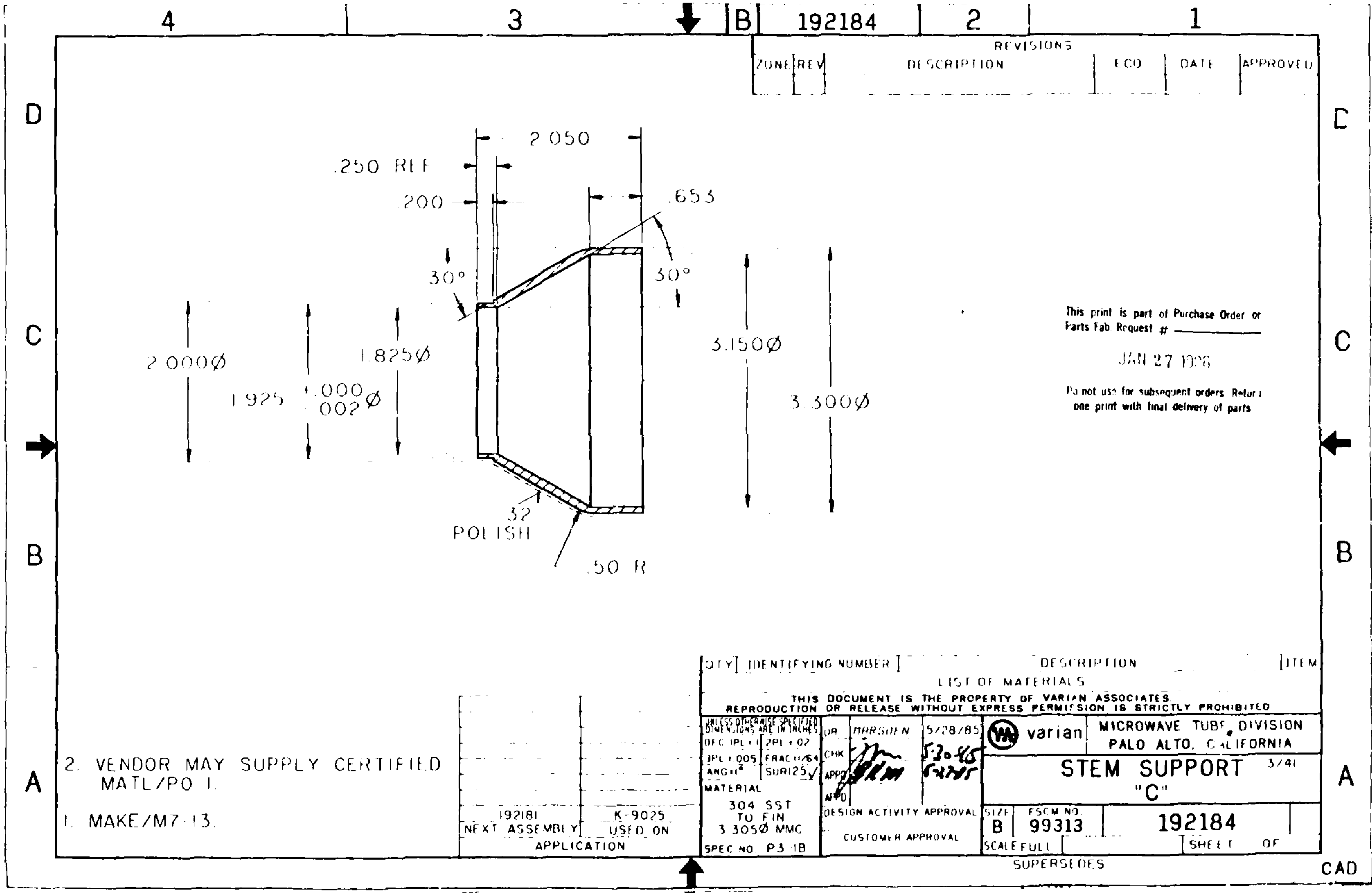

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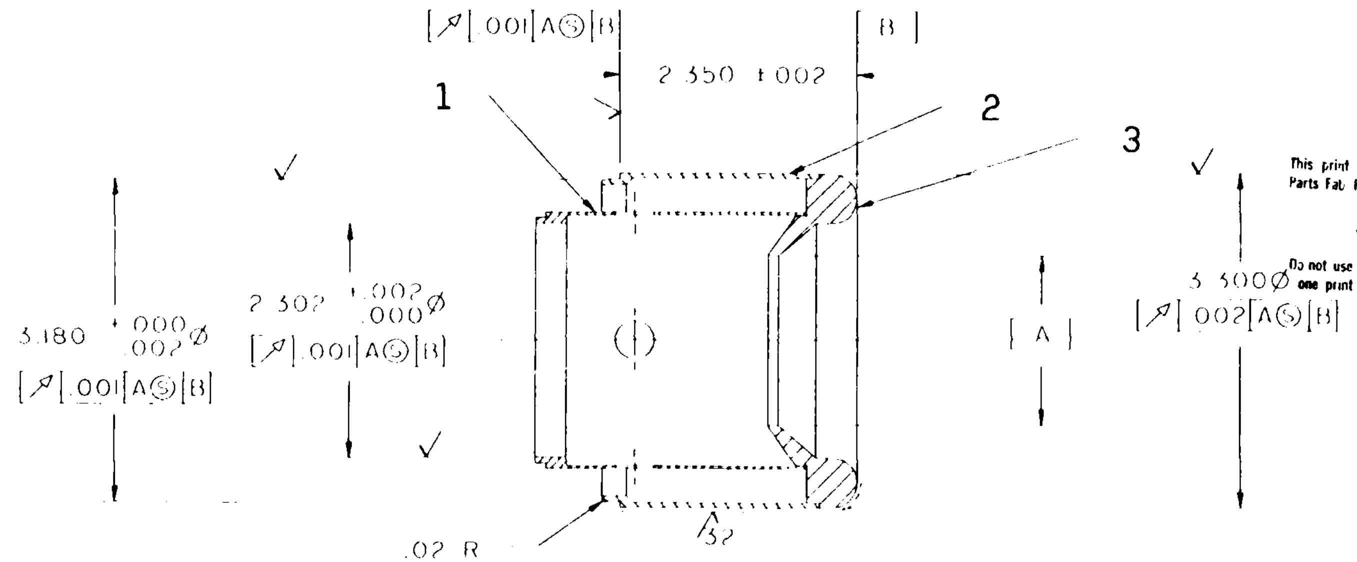

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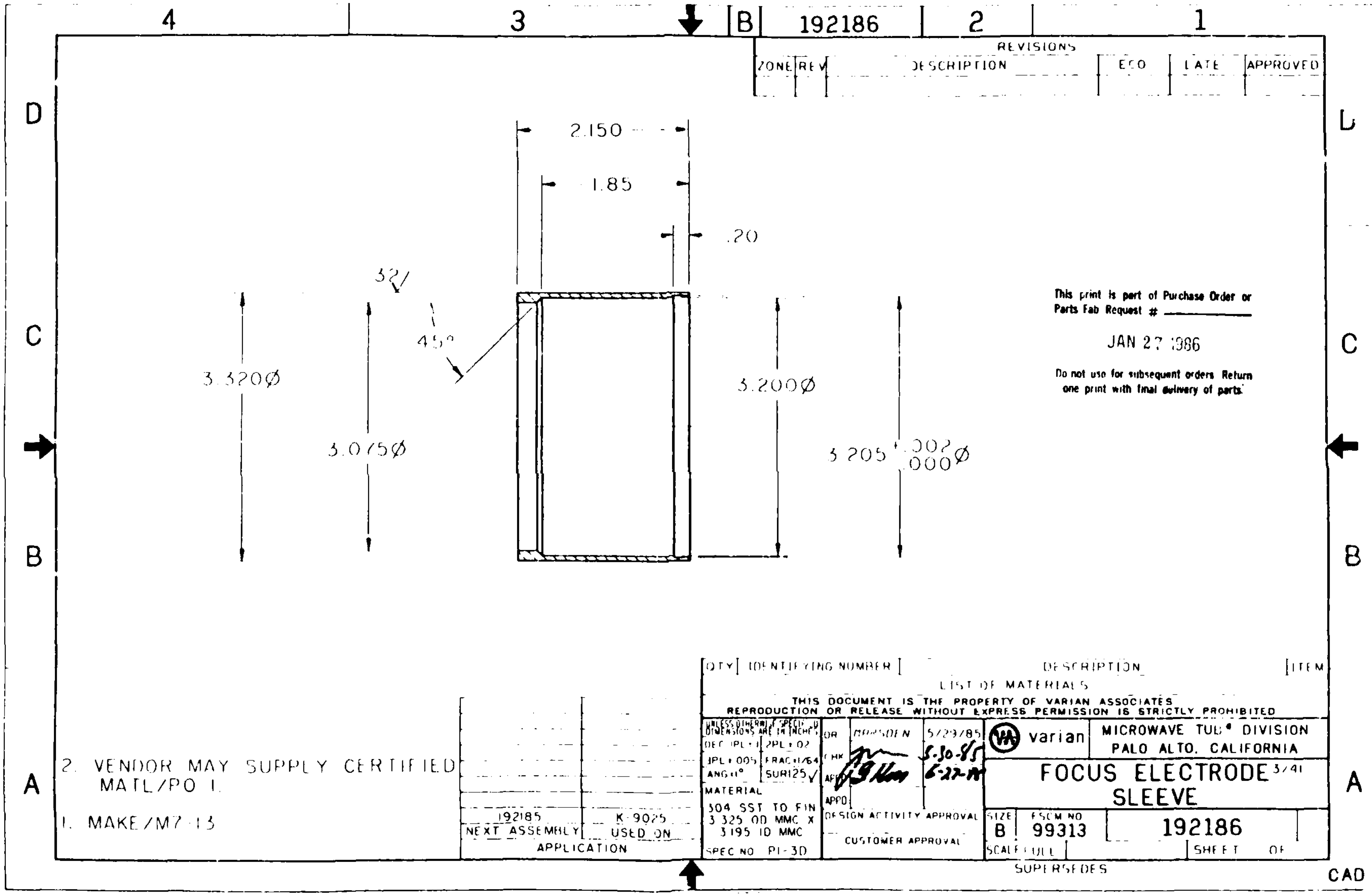
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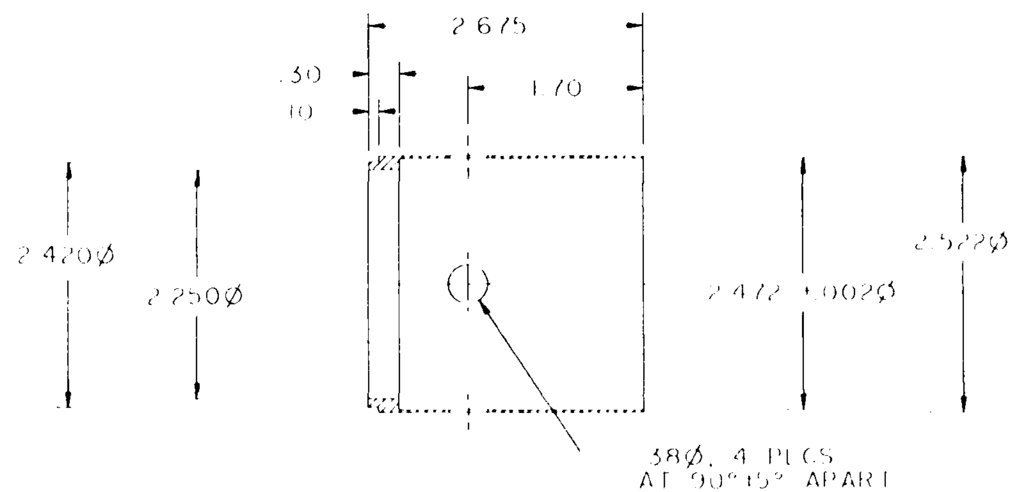
APPD
DESIGN ACTIVITY APPROVAL
CUSTOMER APPROVAL
varian
MICROWAVE TUBE DIVISION
PALO ALTO, CALIFORNIA
FOCUS ELECTRODE 3/41
SLEEVE
SIZE B
FSCM NO 99313
192186
SCALE FULL
SHEET OF
SUPERSEDES
CAD

4 | 3 | B | 192187 | 2 | 1

REVISIONS

ZONE	REV	DESCRIPTION	ECO	DATE	APPROVED



This print is part of Purchase Order or Parts Fab. Request # ________

JAN 27 1996

Do not use for subsequent orders. Return one print with final delivery of parts

QTY	IDENTIFYING NUMBER	DESCRIPTION	ITEM

LIST OF MATERIALS

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REPRODUCTION OR RELEASE WITHOUT EXPRESS PERMISSION IS STRICTLY PROHIBITED

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
DEC 1PL ±.1 2PL ±.02
3PL ±.005 FRAC ±1/64
ANG ±1° SURF 125√

MATERIAL
T 404 MONEL
TO FIN
2.527Ø MMC

SPEC NO P2-5B

DR MARSDEN 6/20/85
CHK 6-20-85
APPD 6-27-85

DESIGN ACTIVITY APPROVAL

CUSTOMER APPROVAL

varian

MICROWAVE TUBE DIVISION
PALO ALTO, CALIFORNIA

CATHODE
SUPPORT SLEEVE

3741

SIZE	FSCM NO	
B	99313	192187

SCALE FULL | SHEET OF

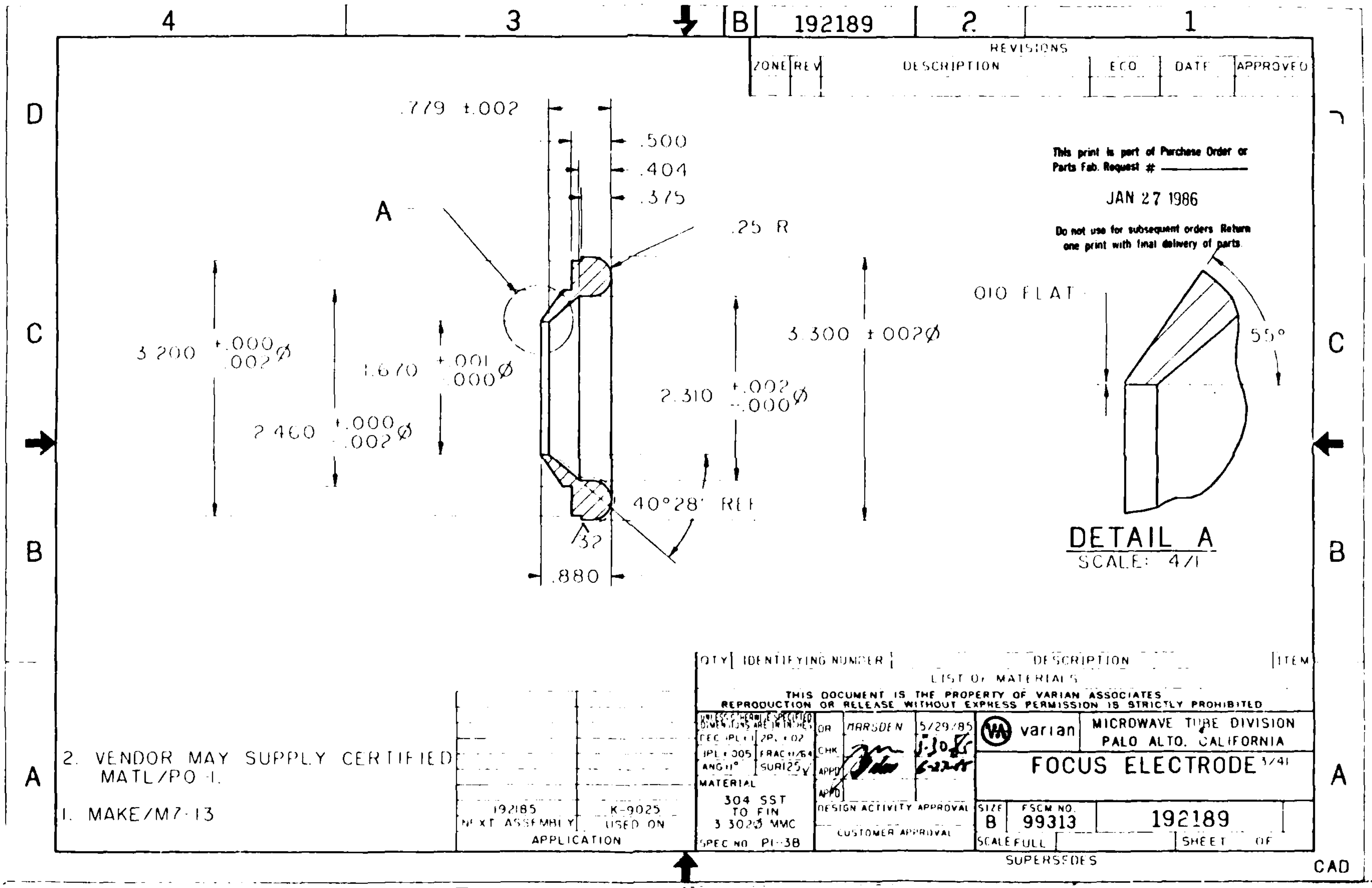
SUPERSEDES

192185	K 9025
NEXT ASSEMBLY	USED ON

APPLICATION

1 MAKE/M7-13

CAD



192189
REVISIONS
ZONE REV DESCRIPTION ECO DATE APPROVED
.779 ±.002
.500
.404
.375
A
.25 R
3.200 +.000 -.002 Ø
1.670 +.001 -.000 Ø
2.460 +.000 -.002 Ø
2.310 +.002 -.000 Ø
3.300 ±.002 Ø
40°28' REF
32
.880
This print is part of Purchase Order or Parts Fab. Request #
JAN 27 1986
Do not use for subsequent orders. Return one print with final delivery of parts.
.010 FLAT
55°
DETAIL A
SCALE: 4/1
2. VENDOR MAY SUPPLY CERTIFIED MATL/PO-1.
1. MAKE/M7-13
192185 NEXT ASSEMBLY
K-9025 USED ON
APPLICATION
QTY IDENTIFYING NUMBER DESCRIPTION ITEM
LIST OF MATERIALS
THIS DOCUMENT IS THE PROPERTY OF VARIAN ASSOCIATES
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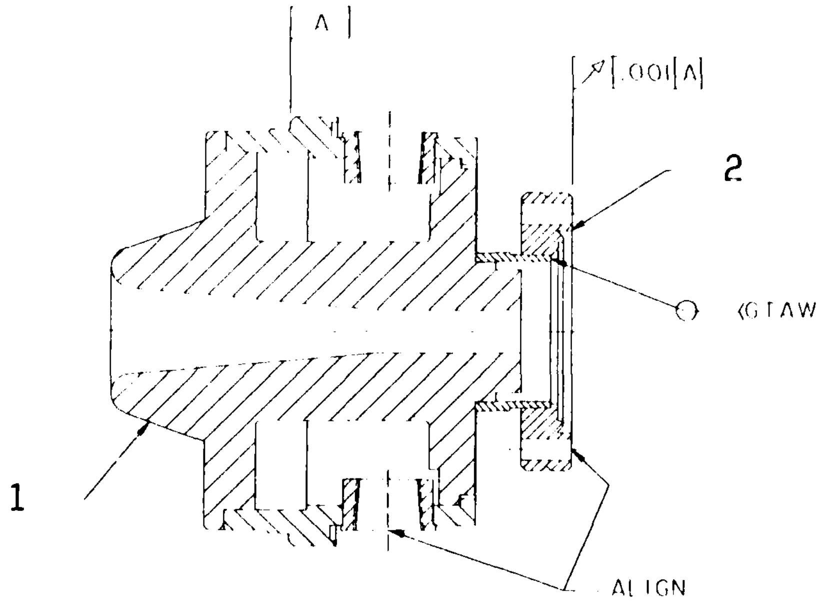
DR MARSDEN 5/29/85
CHK
APPD
MATERIAL
304 SST TO FIN 3.3020 MMC
SPEC NO. PI-38
DESIGN ACTIVITY APPROVAL
CUSTOMER APPROVAL
varian
MICROWAVE TUBE DIVISION
PALO ALTO, CALIFORNIA
FOCUS ELECTRODE
SIZE B
FSCM NO. 99313
192189
SCALE FULL
SHEET OF
SUPERSEDES
CAD



B 192192

REVISIONS

ZONE	REV	DESCRIPTION	ECO	DATE	APPROVED

This print is part of Purchase Order or Parts Fab Request # ____

JAN 27 1986

Do not use for subsequent orders. Return one print with final delivery of parts.

QTY	IDENTIFYING NUMBER	DESCRIPTION	ITEM
1		2.75Ø CONFLAT VA #954-5071	2
1	192193	ANODE ASSY -MACH	1

LIST OF MATERIALS Hudit

THIS DOCUMENT IS THE PROPERTY OF VARIAN ASSOCIATES REPRODUCTION OR RELEASE WITHOUT EXPRESS PERMISSION IS STRICTLY PROHIBITED

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
DEC 1PL ±.1 2PL ±.02
3PL ±.005 FRAC ±1/64
ANG ±1° SUR 125 ✓
MATERIAL
NOTED

DR MARSDEN 6/1/85
CHK 6-4-85
APPD 6-27-85

DESIGN ACTIVITY APPROVAL
CUSTOMER APPROVAL

varian MICROWAVE TUBE DIVISION PALO ALTO, CALIFORNIA

ANODE & CONFLAT ASSY

SIZE B FSCM NO 99313 192192

SCALE FULL SHEET OF

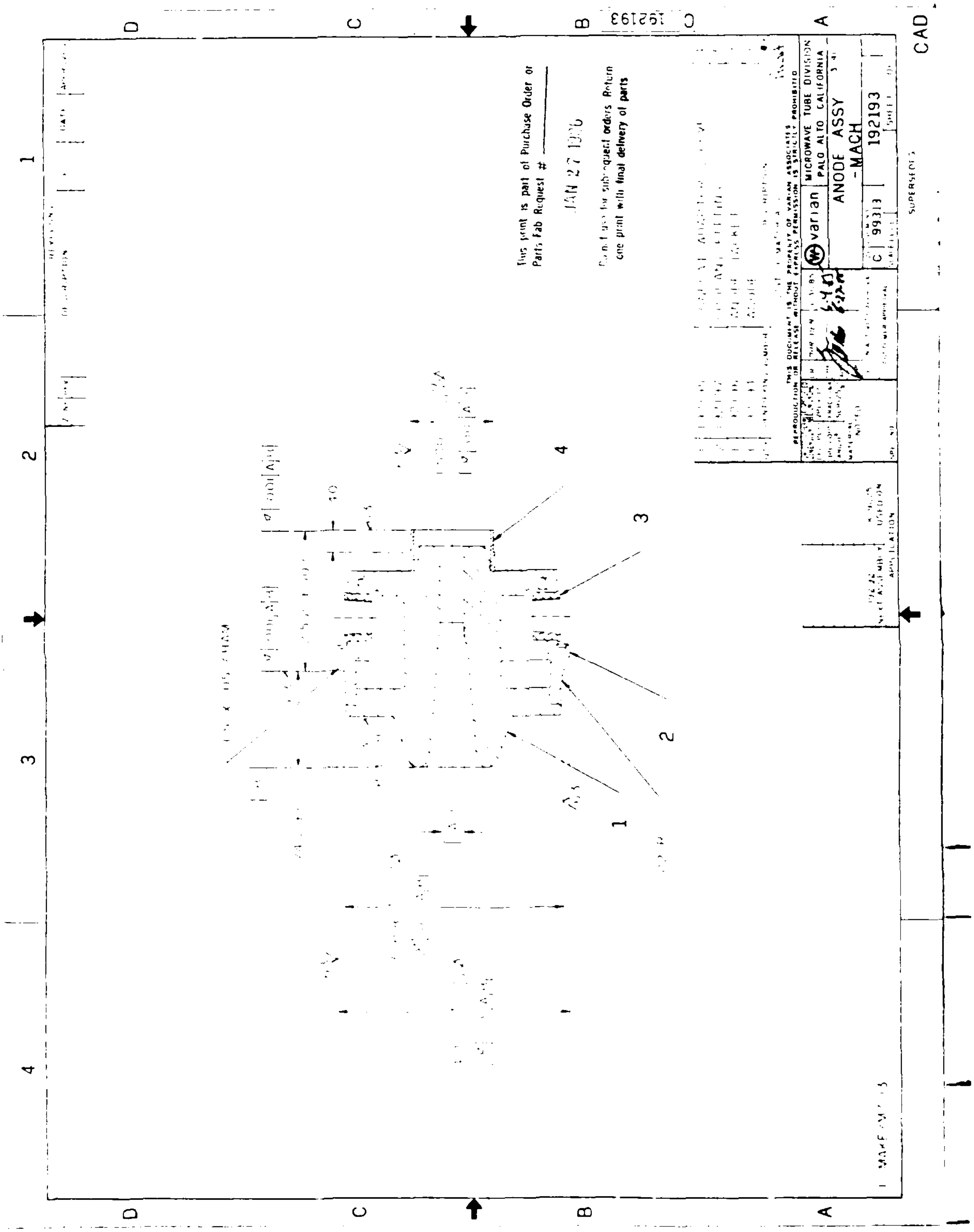
NEXT ASSEMBLY K 2025 USED ON
APPLICATION

SPEC NO

SUPERSEDES

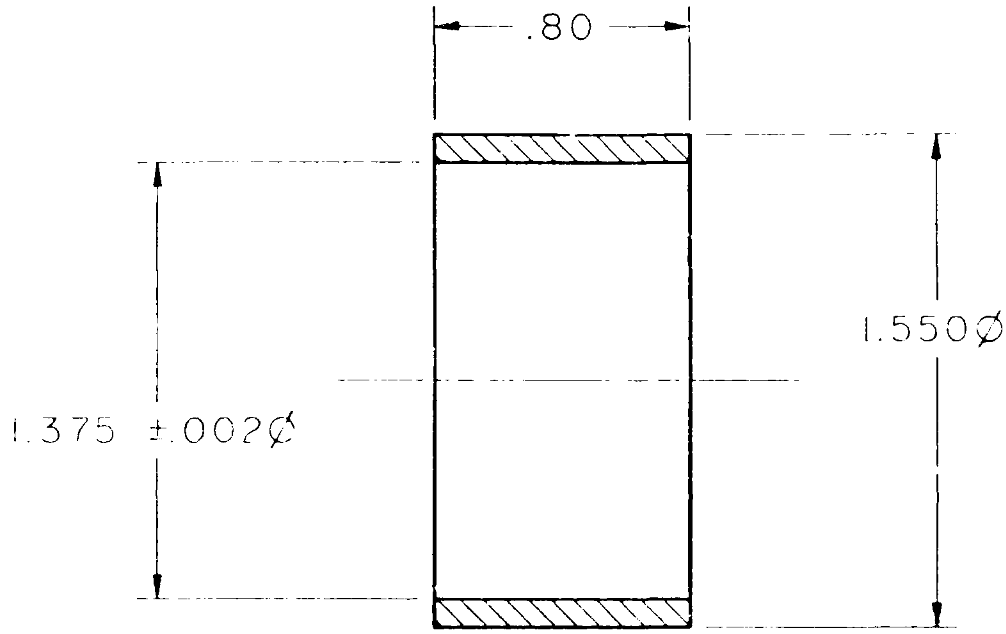
CAD


varian MICROWAVE TUBE DIVISION
PALO ALTO CALIFORNIA
ANODE


This print is part of Purchase Order or Parts Fab Request #
JAN 27 1986
varian
MICROWAVE TUBE DIVISION
PALO ALTO CALIFORNIA
ANODE ASSY -MACH
99313
192193
SUPERSEDES
CAD

A 192195

APPLICATION		REVISIONS				
NEXT ASSEMBLY	USED ON	REV	DESCRIPTION	ECO	DATE	APPROVED
192193	K-9025					



This print is part of Purchase Order or Parts Fab. Request # ____

JAN 27 1986

Do not use for subsequent orders. Return one print with final delivery of parts

2. VENDOR MAY SUPPLY CERTIFIED MATL/PO-1.

1. MAKE/M7-13.

QTY	IDENTIFYING NUMBER	DESCRIPTION	ITEM

LIST OF MATERIALS

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES				
DEC: 1PL ±.1	2PL ±.02	DR	MARSDEN	5/30/85
3PL ±.005	FRAC ±1/64	CHK		5-30-85
ANG ±1°	SUR 125√	APPD		6-27-85
		APPD		

MATERIAL
304 SST TO FIN
1.555 OD MMC X
1.370 ID MMC
SPEC NO. P1-3D

DESIGN ACTIVITY APPROVAL

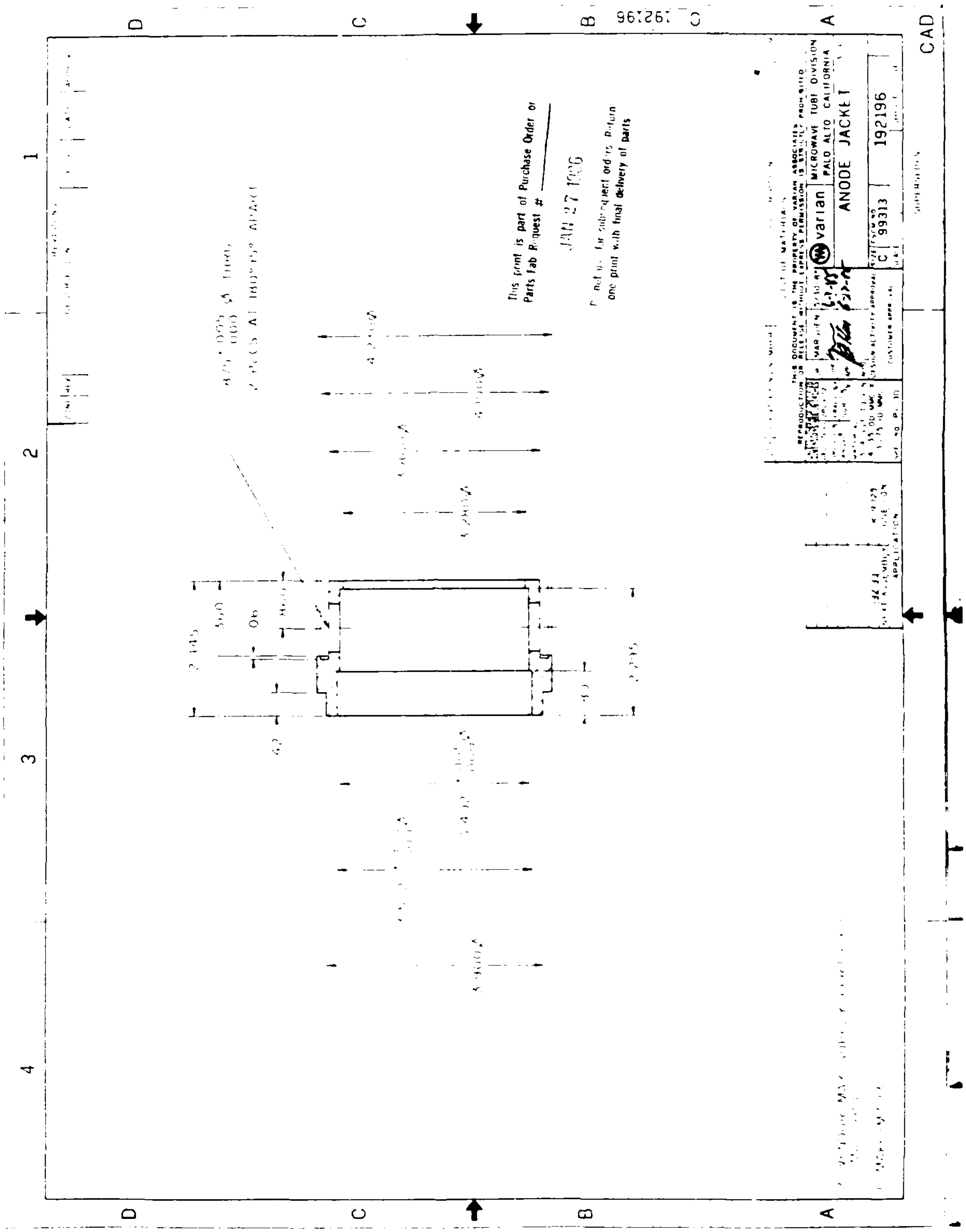
CUSTOMER APPROVAL

varian — MICROWAVE TUBE DIVISION, PALO ALTO, CALIFORNIA

CONFLAT ADAPTER SLEEVE

3/41

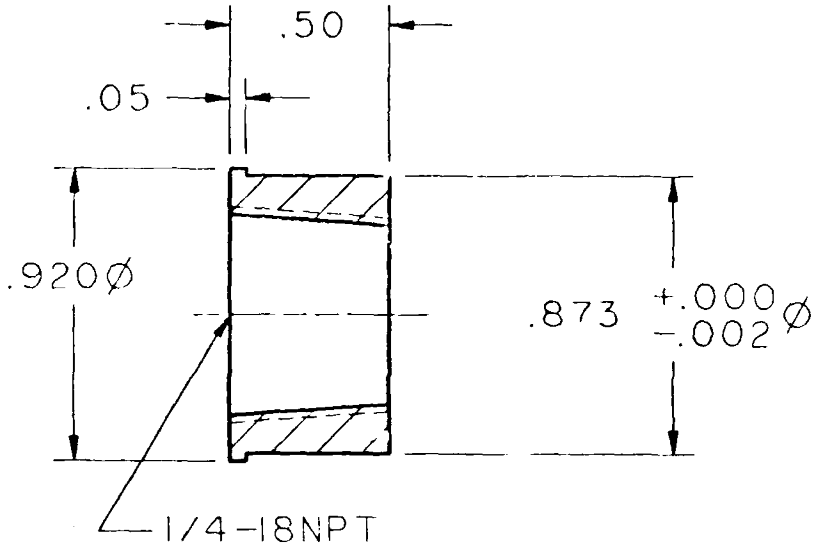
SIZE	FSCM NO.	
A	99313	192195
SCALE 2/1		SHEET OF



This print is part of Purchase Order or Parts Fab Request #
JAN 27 1986
one print with final delivery of parts
varian
MICROWAVE TUBE DIVISION
PALO ALTO CALIFORNIA
ANODE JACKET
99313
192196
CAD

A 192197

APPLICATION		REVISIONS				
NEXT ASSEMBLY	USED ON	REV	DESCRIPTION	ECO	DATE	APPROVED
192193	K-9025					



This print is part of Purchase Order or Parts Fab. Request # ______

JAN 27 1986

Do not use for subsequent orders. Return one print with final delivery of parts

2. VENDOR MAY SUPPLY CERTIFIED MATL/PO-1.

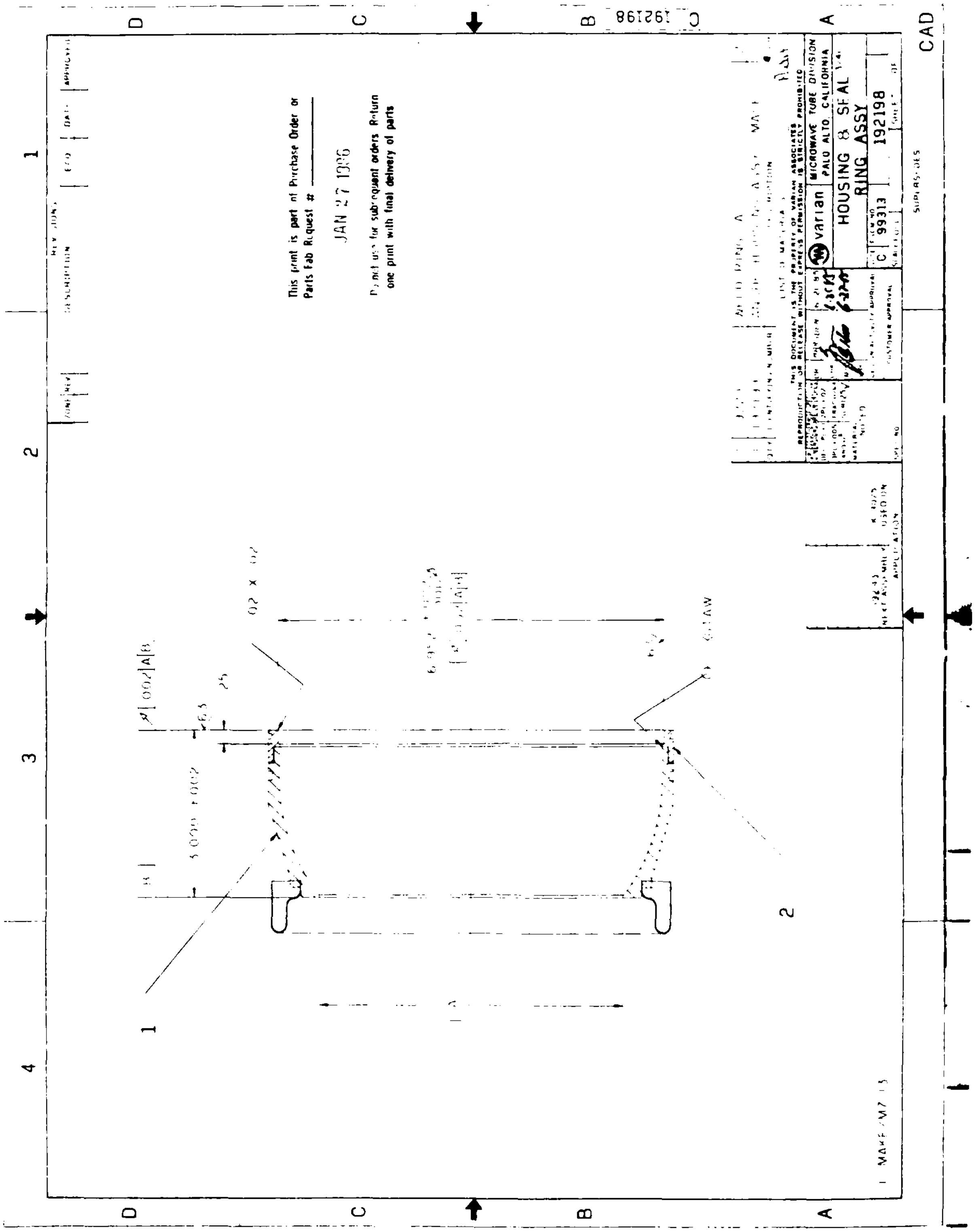
1. MAKE/M7-13.

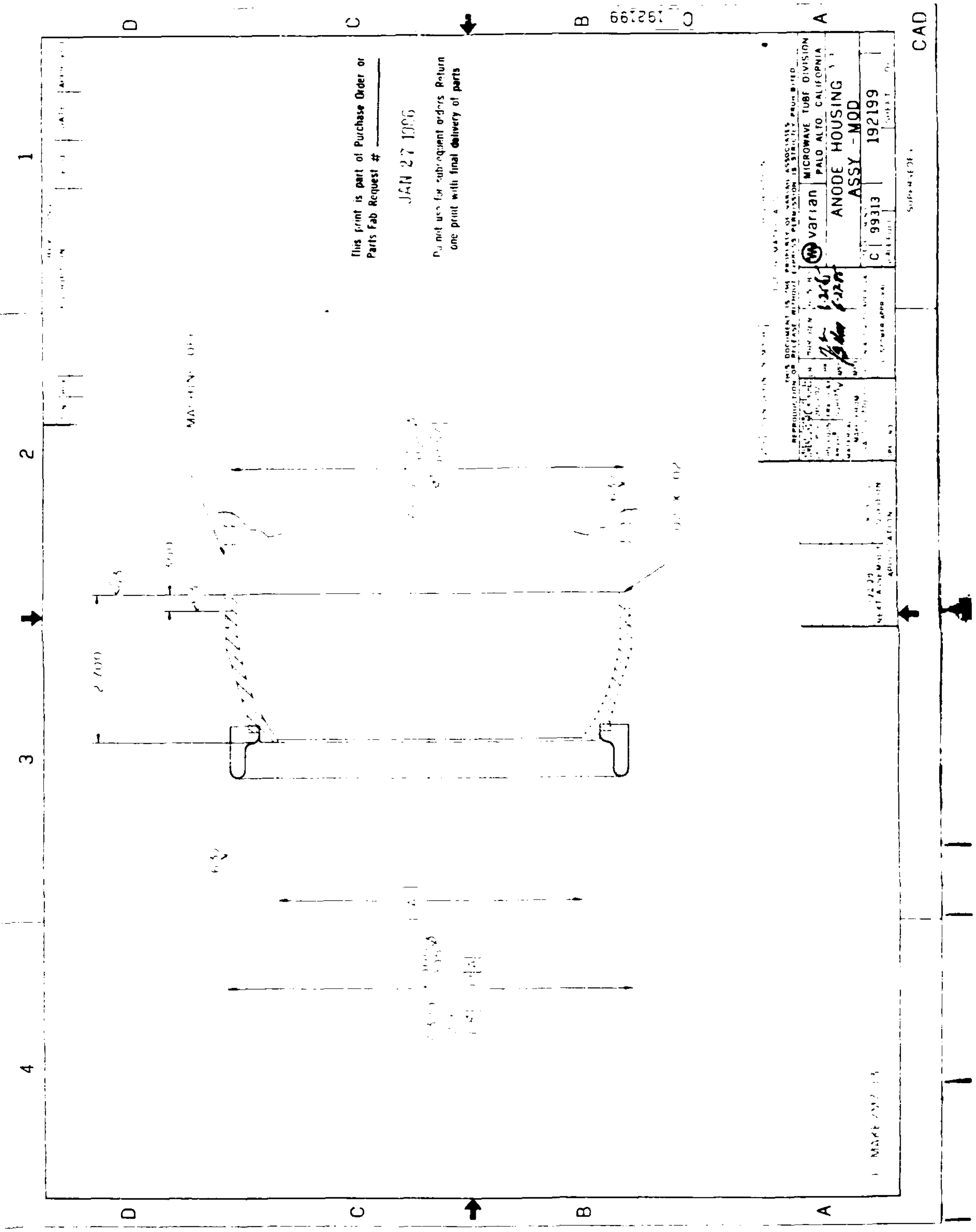
QTY	IDENTIFYING NUMBER	DESCRIPTION	ITEM

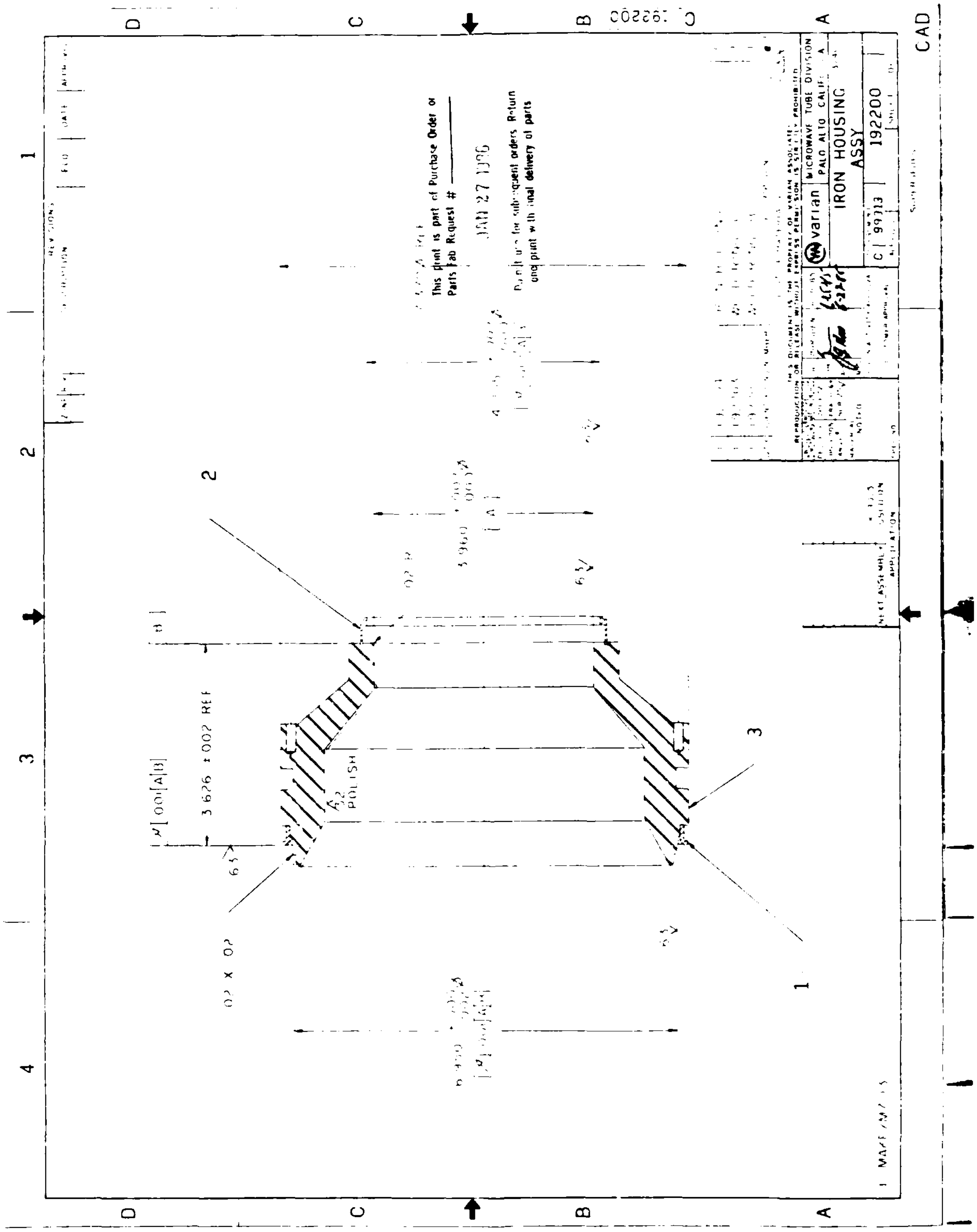
LIST OF MATERIALS

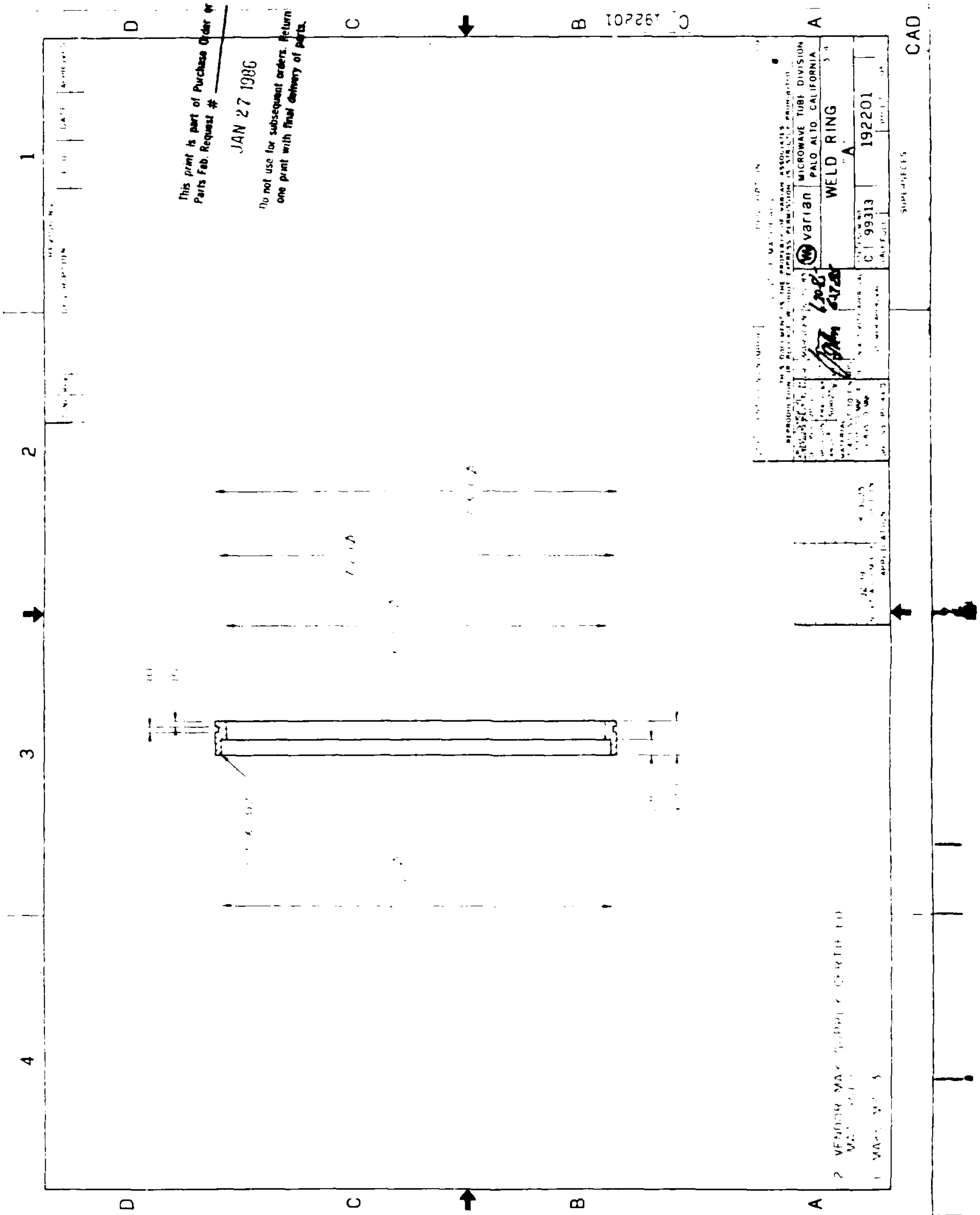
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	DR	MARSDEN	5/30/85	varian — MICROWAVE TUBE DIVISION, PALO ALTO, CALIFORNIA
DEC: 1PL ±.1 2PL ±.02	CHK	[signature]	5-30-85	
3PL ±.005 FRAC ±1/64	APPD	[signature]	6-27-85	COOLANT FITTING 3/41
ANG ±1° SUR 125√	APPD			
MATERIAL 304 SST TO FIN .925Ø MMC	DESIGN ACTIVITY APPROVAL			SIZE A, FSCM NO. 99313, 192197
SPEC NO. P1-3B	CUSTOMER APPROVAL			SCALE 2/1, SHEET OF

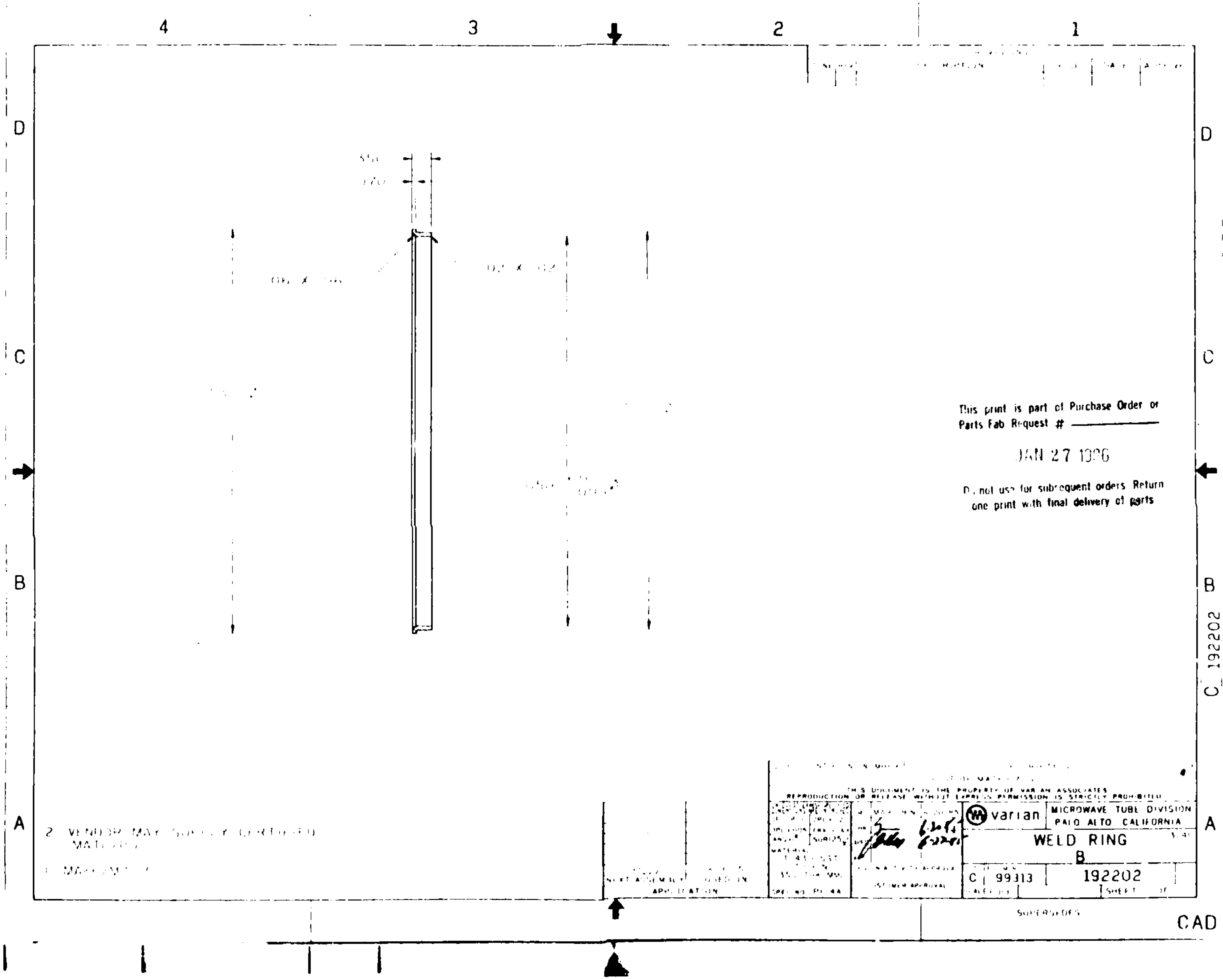
CA

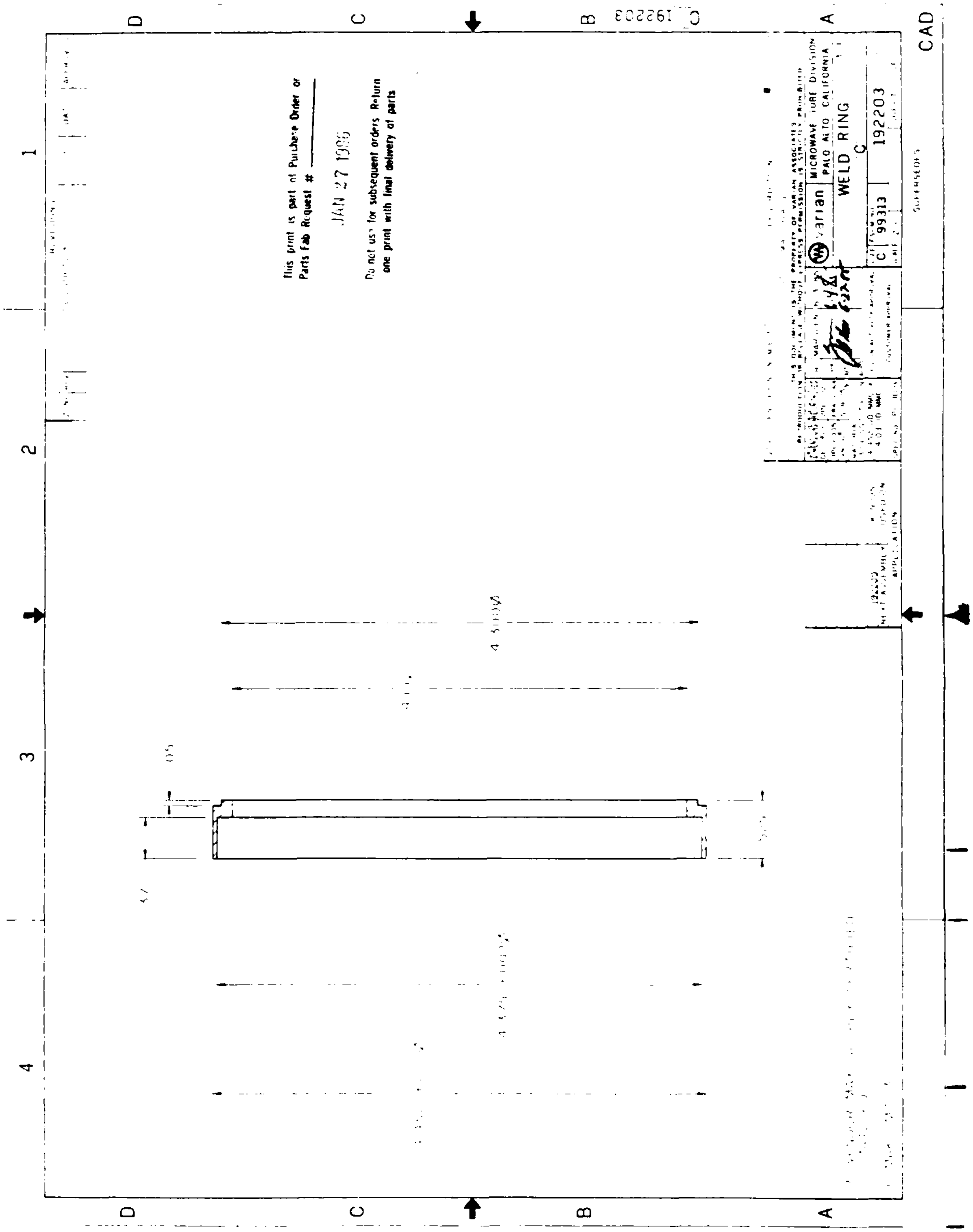

This print is part of Purchase Order or Parts Fab Request #
JAN 27 1986
Do not use for subsequent orders. Return one print with final delivery of parts
varian
MICROWAVE TUBE DIVISION
PALO ALTO, CALIFORNIA
HOUSING & SEAL RING ASSY
C
99313
192198
C 192198
CAD
1
2

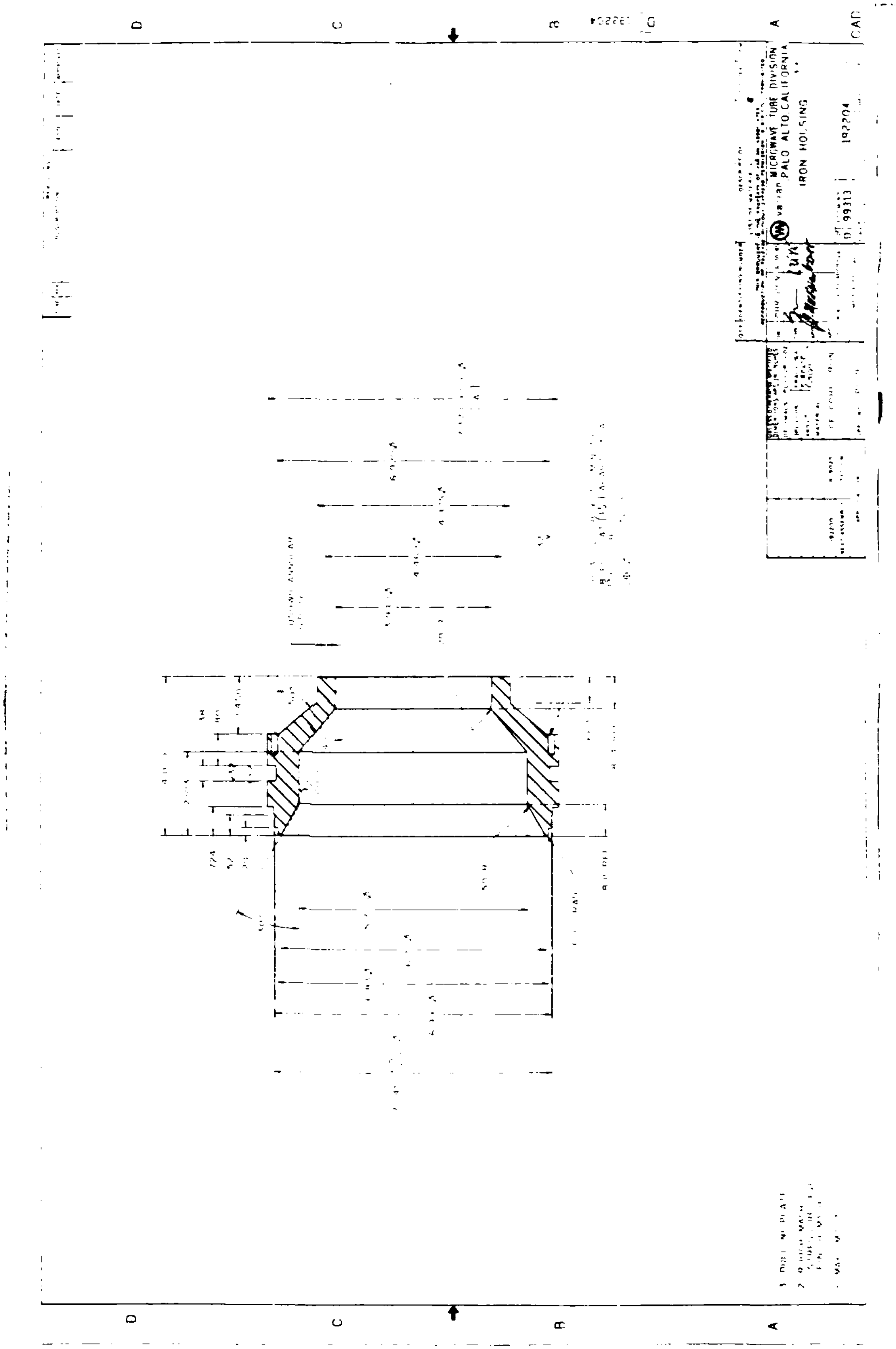

This print is part of Purchase Order or
Parts Fab Request #
JAN 27 1986
Do not use for subsequent orders. Return one print with final delivery of parts
varian MICROWAVE TUBE DIVISION
PALO ALTO CALIFORNIA
ANODE HOUSING
ASSY - MOD
C 99313
192199
C 192199
CAD
2.700

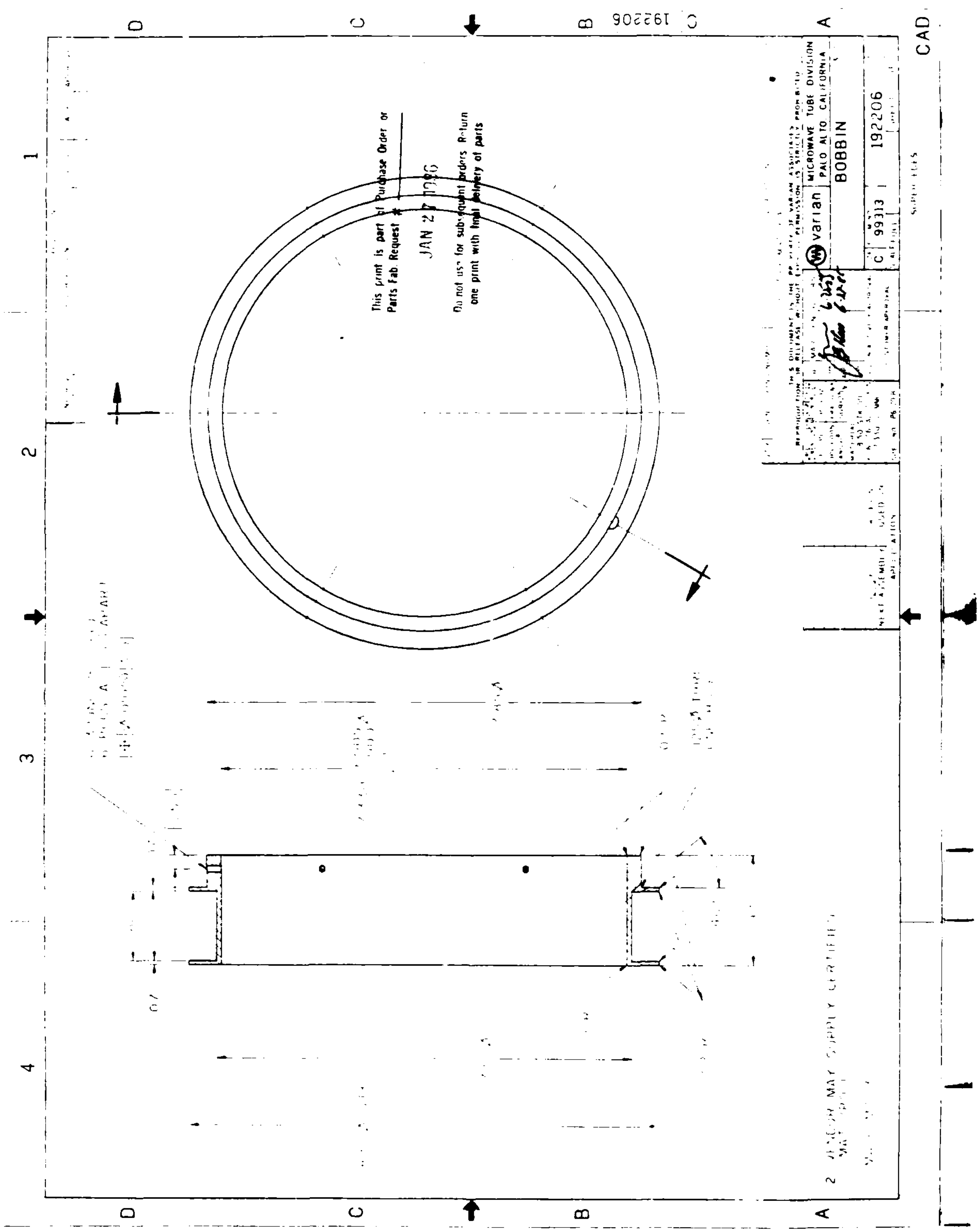

IRON HOUSING
ASSY
192200
varian
MICROWAVE TUBE DIVISION
PALO ALTO CALIF.
This print is part of Purchase Order or
Parts Fab Request #
CAD
3.626 ±.002 REF
POLISH
.02 X .02

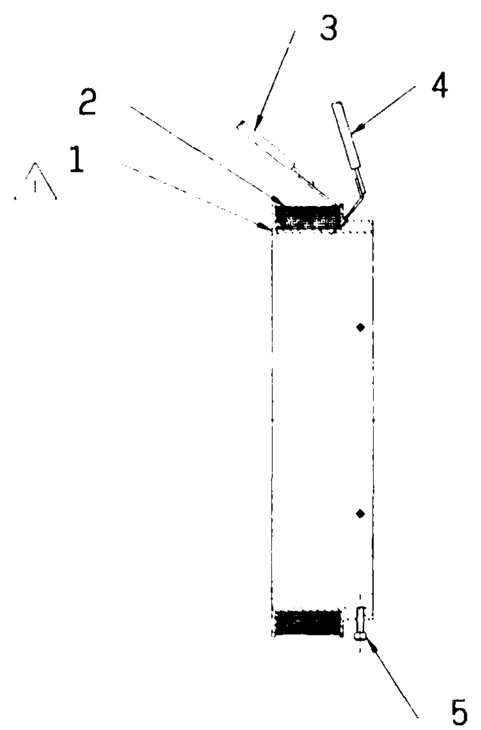

This print is part of Purchase Order or Parts Fab. Request #
JAN 27 1986
Do not use for subsequent orders. Return one print with final delivery of parts.
varian
MICROWAVE TUBE DIVISION
PALO ALTO CALIFORNIA
WELD RING
A
C 99313
192201
CAD


This print is part of Purchase Order or
Parts Fab Request #
JAN 27 1986
Do not use for subsequent orders. Return
one print with final delivery of parts
varian
MICROWAVE TUBE DIVISION
PALO ALTO CALIFORNIA
WELD RING
B
C 99313
192202
C 192202
CAD


This print is part of Purchase Order or Parts Fab Request #
JAN 27 1986
Do not use for subsequent orders. Return one print with final delivery of parts
varian MICROWAVE TUBE DIVISION
PALO ALTO CALIFORNIA
WELD RING
C 99313
192203
SUPERSEDES
CAD
C 192203


MICROWAVE TUBE DIVISION
PALO ALTO, CALIFORNIA
IRON HOUSING
99313
192204


C 192206
This print is part of Purchase Order or Parts Fab. Request #
JAN 27 1986
Do not use for subsequent orders. Return one print with final delivery of parts
varian
MICROWAVE TUBE DIVISION
PALO ALTO CALIFORNIA
BOBBIN
C 99313
192206
CAD



B 192207

REVISIONS

ZONE	REV	DESCRIPTION	ECO	DATE	APPROVED

This print is part of Purchase Order or Parts Fab Request #

JAN 27 1986

Use Rev for subsequent orders. Return one print with final delivery of parts

QTY	IDENTIFYING NUMBER	DESCRIPTION	ITEM
6	12 312 006 08	6-32UNC 2A X .50LG SOC HD CAP SCR, SST	5
1	81 249 982	16AWG WIRE, RED (3FT)	4
1	81 249 986	16AWG WIRE, BLUE (3FT)	3
AR	81 101 918	18AWG MAGNET WIRE	2
1	192206	BOBBIN	1

LIST OF MATERIALS

1 250 TURNS

NEXT ASSEMBLY | K 9025 USED ON
APPLICATION

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UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
DEC 2PL ±.02 3PL ±.005 FRAC ±1/64 ANG ±1° 125√
MATERIAL NOTED
SPEC NO

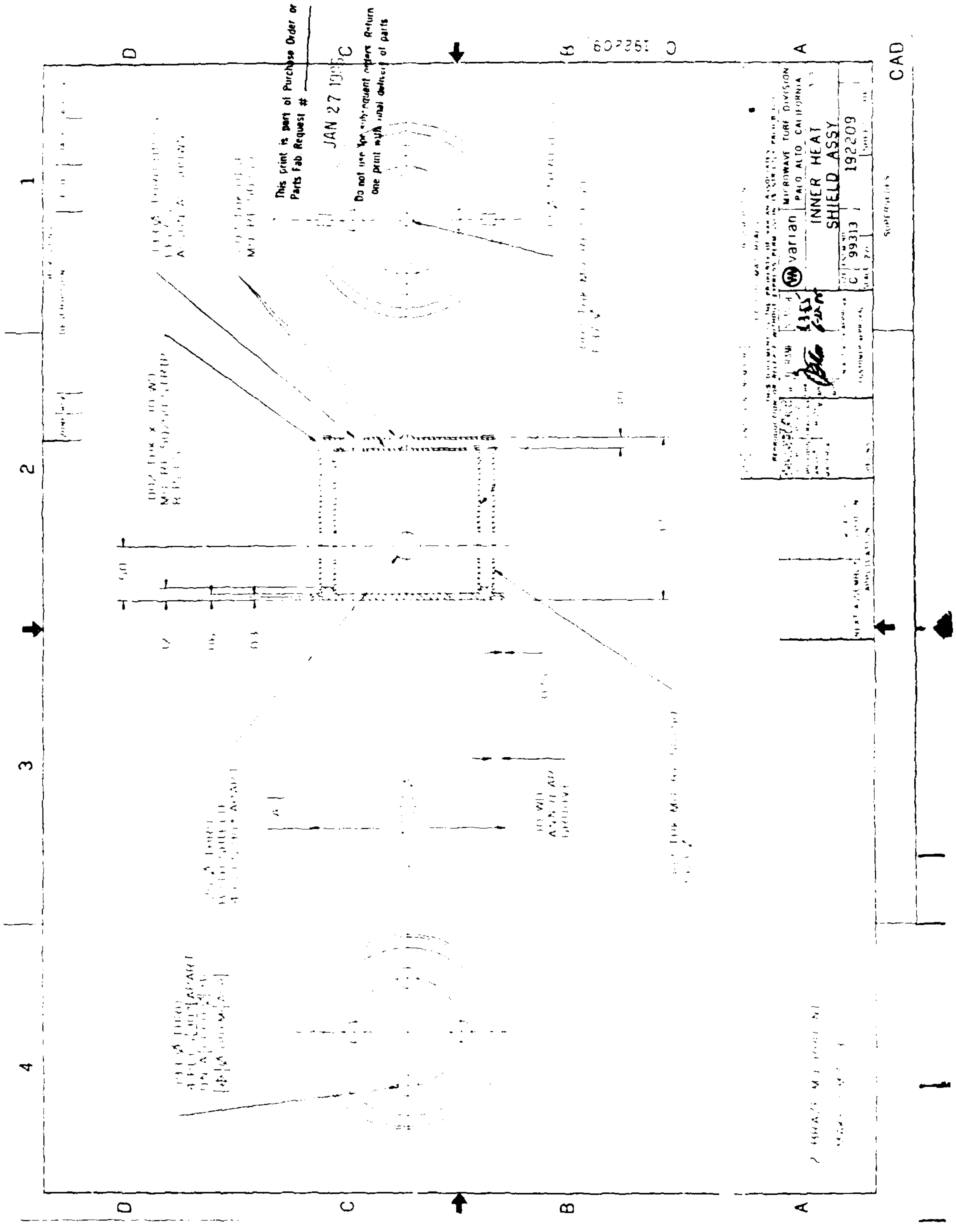
DR HARSDEN 6.25.85
CHK 6.22.85
APPD
DESIGN ACTIVITY APPROVAL
CUSTOMER APPROVAL

varian MICROWAVE TUBE DIVISION PALO ALTO, CALIFORNIA

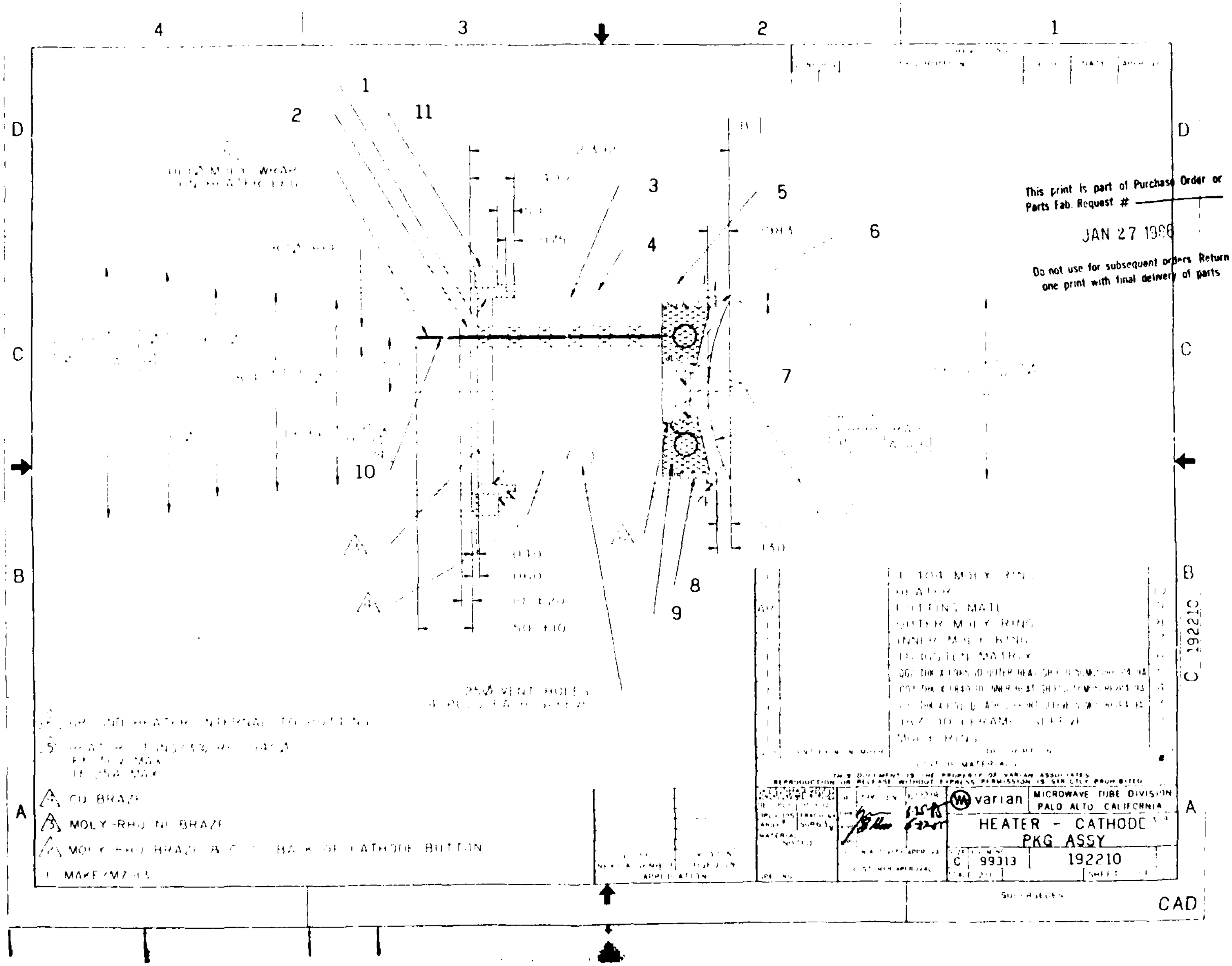
GUN COIL

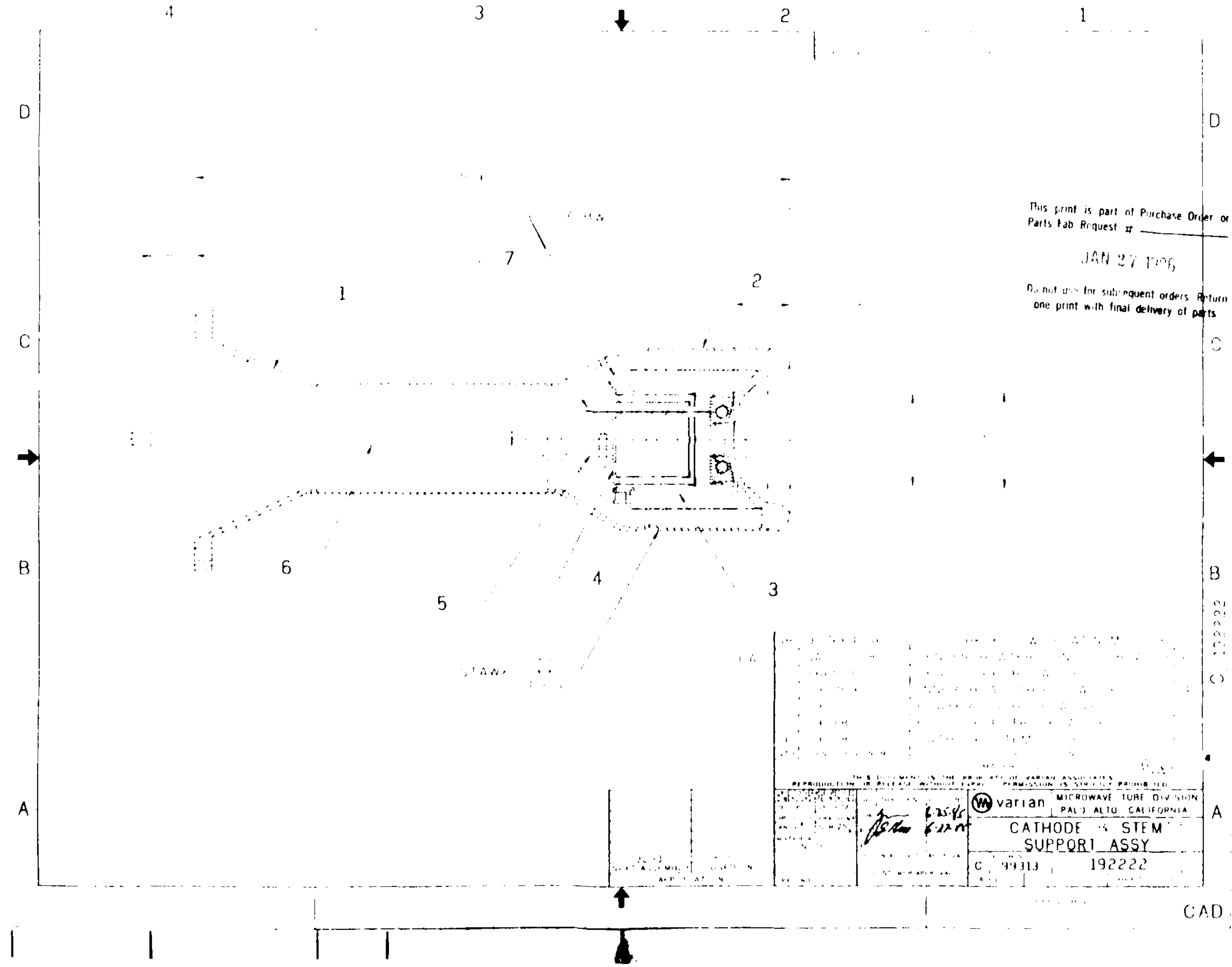
SIZE B FSCM NO 99313 192207
SCALE 1/2 SHEET OF
SUPERSEDES

CAD



This print is part of Purchase Order or Parts Fab Request #
Do not use for subsequent orders Return one print with final delivery of parts
varian
MICROWAVE TUBE DIVISION
PALO ALTO, CALIFORNIA
INNER HEAT SHIELD ASSY
99313
192209
CAD

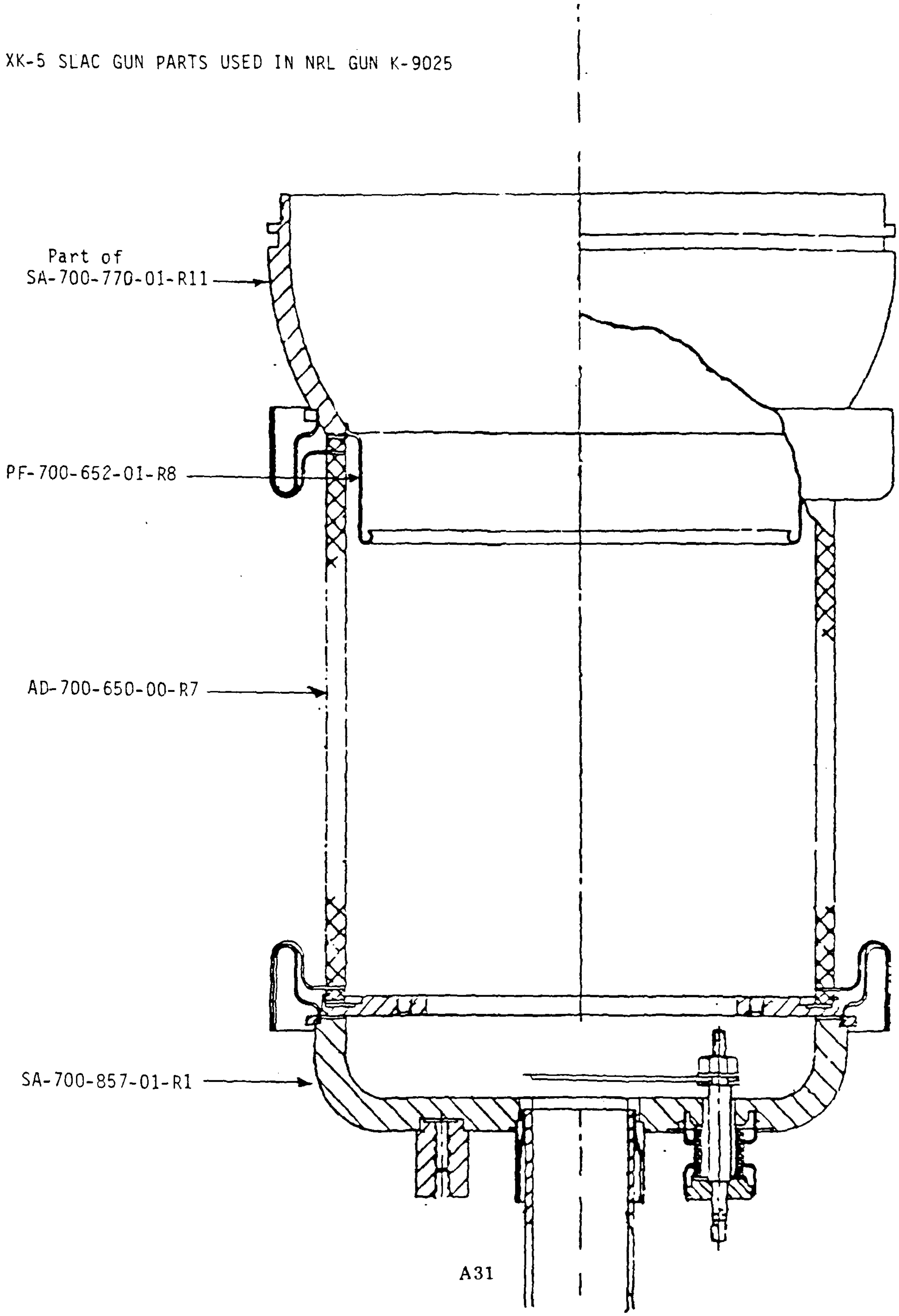

This print is part of Purchase Order or Parts Fab. Request #
JAN 27 1986
Do not use for subsequent orders. Return one print with final delivery of parts
1
2
11
3
4
5
6
7
8
9
10
CU BRAZE
MOLY-RHO NI BRAZE
MAKE/MZ-15
varian
MICROWAVE TUBE DIVISION
PALO ALTO CALIFORNIA
HEATER - CATHODE
PKG ASSY
99313
192210
CAD


This print is part of Purchase Order or Parts Fab Request #
JAN 27 1986
Do not use for subsequent orders. Return one print with final delivery of parts
varian
MICROWAVE TUBE DIVISION
PALO ALTO CALIFORNIA
CATHODE & STEM SUPPORT ASSY
C 99313
192222
CAD

APPENDIX A-3

DETAIL PARTS DRAWINGS
(SLAC)

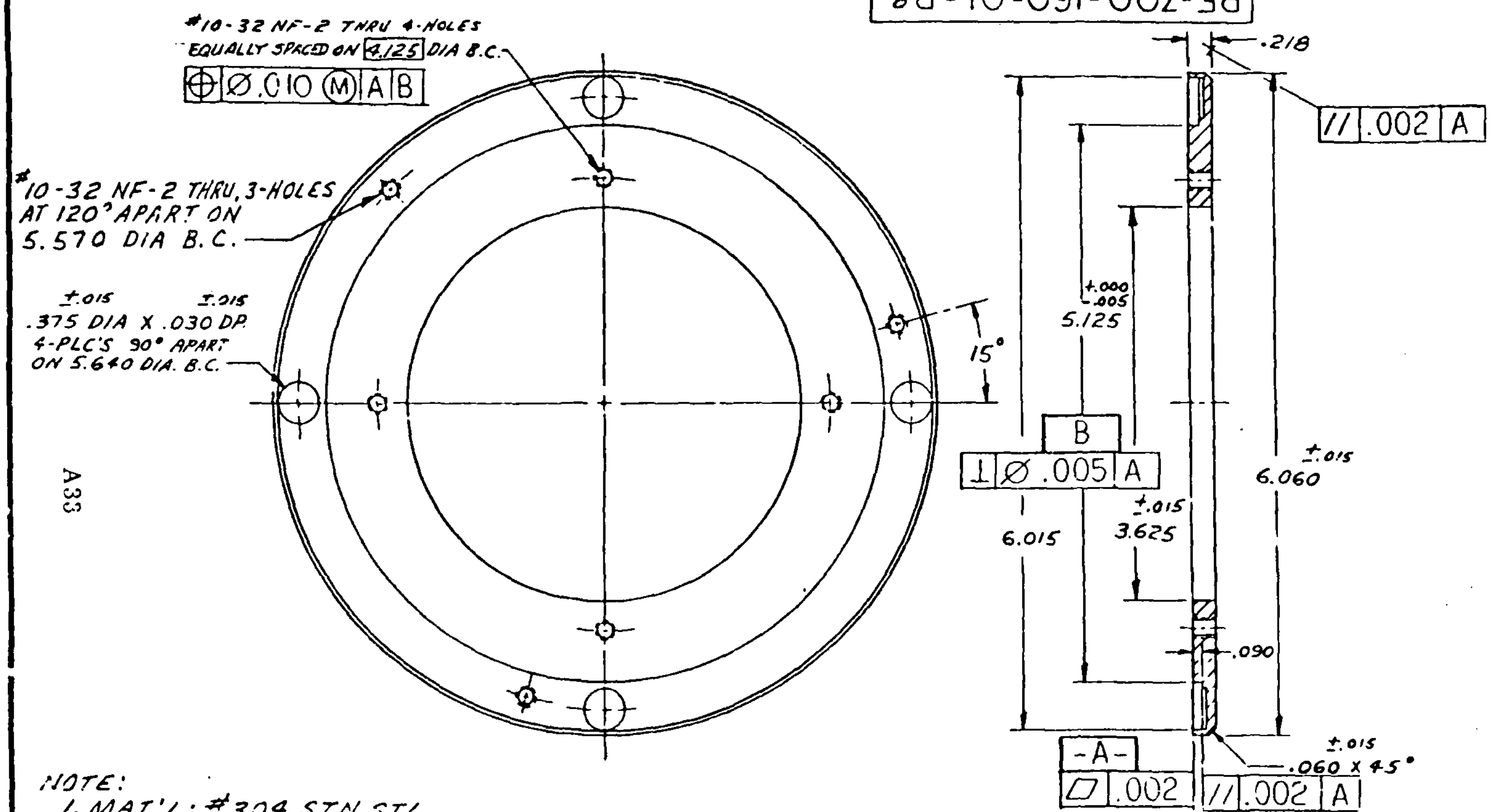
XK-5 SLAC GUN PARTS USED IN NRL GUN K-9025



XK-5 SLAC PARTS USED IN NRL GUN K-9025

Title	Part No.
Base-2 Gun Mount	PF-700-160-01-R8
Cath. Holdown Screw	212-01-R5
Ring Reinforcing	227-01-R6
Slip Ring	228-01-R7
Cylinder, Ctr. Heater	229-01-R9
Base Cup, Forming	287-01-R5
Cup, Base-finished	288-01-R15
Take-apart Joint-outer	297-01-R10
Anode Housing Blank	301-03-R10
Ring, Back Up	648-01-R5
Ceramic	649-01-R3
Assy, Seal-ceramic	AD-700-650-00-R7
Ring, Corona	PF-700-652-01-R8
Cup, Sealing-male	654-01-R7
Tube, Pumpout	655-01-R5
Housing, Anode	682-01-R15
Rod, Center Heater	759-01-R7
Assy, Anode Shell (Mach)	SA-700-770-01-R11
Asm. Ctr. Heater Cond.	783-01-R4
Assy Pumpout	857-17-R0
Ring, PL-back Up	PF-700-862-04-R0
Ceramic, Plated	862-05-R0
Assembly, Base Cup	SA-700-857-01-R1

PF-700-160-01-R8

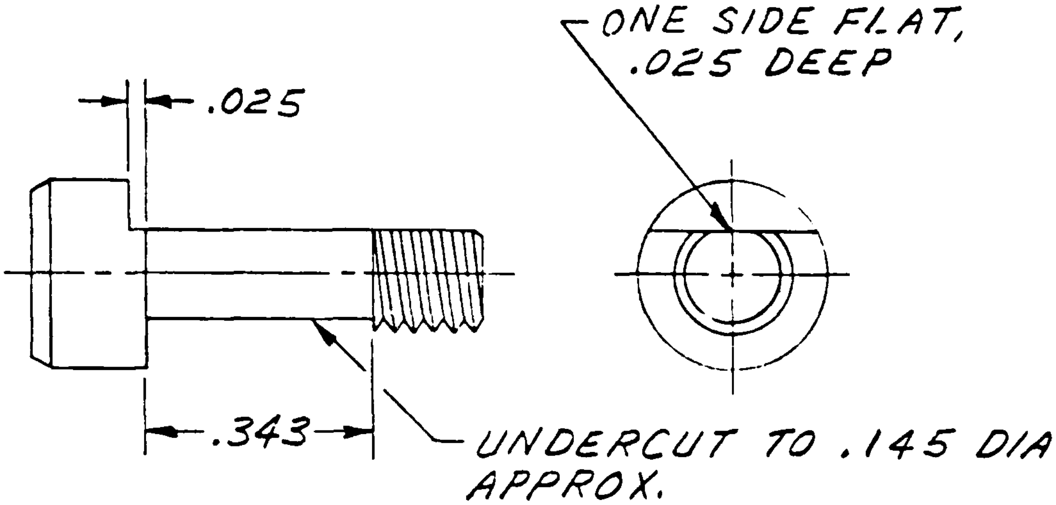


NOTE:
1. MAT'L: #304 STN STL
2. STRESS RELIEVE AT 950-1000°C. FOR 10-20 MIN. WITH FAST COOL BEFORE FINAL MACHINING
3. USE ONLY SLAC APPROVED MACHINING FLUIDS PER SC-700-866-47.
4. NEXT ASSY: AD-704-011-00

REV.	DESCRIPTION	DRN.	DATE	APP.	DATE
R8	TOL. ON 5.125 DIA WAS ±.005	H.G.	2-6-80		
R8	ADDED GEOM. TOLER - NOTES 3&4	J.G.	1-4-84	R.T.H.	1-11-84
R7	REV. NOTES	H.G.	10-20-		

UNLESS NOTED

STANFORD LINEAR ACCELERATOR—M U.S. ATOMIC ENERGY COMMISSION	TITLE BASE-2, GUN MOUNT XK-5 KLYSTRON
ENGR. CHK'D H.G. DFTS GREENHILL APP'D NELONI	DATE 6-11-62 SCALE 1:1 PF-700-160-01-R8



NOTE:

1. MADE FROM ST'D #10-32 NF-2 X 1/2 LG. SOC HD CAP SCR, #304 STN STL
2. USE ONLY SLAC APPROVED MACHINING FLUIDS PER SC-700-866-47.
3. NEXT ASSY: AD-704-011-00

SCALE: 4" = 1"

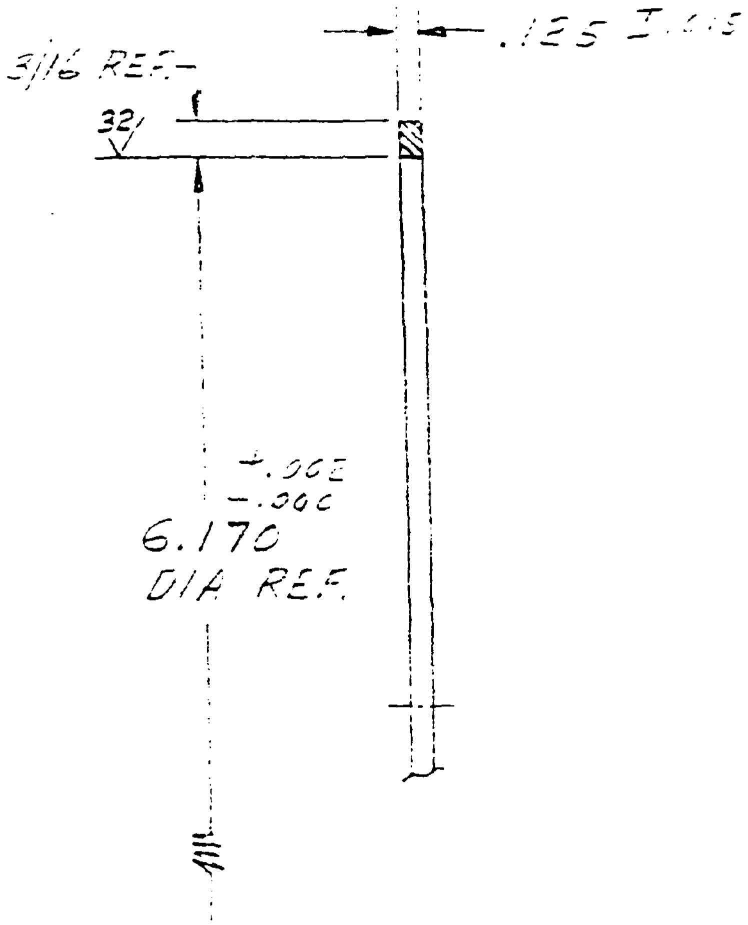
REV.	DESCRIPTION	DRN.	DATE	APP.	DATE
R3	REDRAWN & REVISED	H.G.	6-6-72	[illegible]	[illegible]
R4	CHG. TITLE	B.E.	11-15-70	[illegible]	11-15-[illegible]
R5	ADDED NOTE 2 & 3	J.G.	12-30-[illegible]	RTH	1/11/84

STANFORD LINEAR ACCELERATOR CENTER
U. S. ATOMIC ENERGY COMMISSION
STANFORD UNIVERSITY STANFORD, CALIFORNIA

ENGR R. CALLIN
DFTS H. GREENHILL
CHK [illegible]
APPROVALS [illegible]

CATH HOLDOWN SCREW XK-5 KLYSTRON

PF-700-212-01-R5 A



NOTE:
1. MADE FROM PF-700-768-01

SCALE: 1" = 1"

UNLESS NOTED
TOLERANCES
FRACT ± 1/64
DEC. ±.005
ANGLES ± 1/2°
BREAK CORNERS .015
63

REV.	DESCRIPTION	DRN.	DATE	APP.	DATE
R2	REVISED & REDRAWN	H.G.	10-13-67	P.M.	10-13-67
R3	.032 X .032 BRAZE GROOVE WAS .042 X .042	H.G.	11-28-67	R.S.	11-28-67
R4	CHG. TITLE	H.G.	8-19-70	RLC	8-19-70
R5	CHG. TITLE	H.G.	11-18-76	R.E.L.	11-18-76
R6	DEL. BRZ. GROOVE	SS	1-22-80	H.G.	1-22-80

STANFORD LINEAR ACCELERATOR CENTER
U. S. ATOMIC ENERGY COMMISSION
STANFORD UNIVERSITY STANFORD, CALIFORNIA

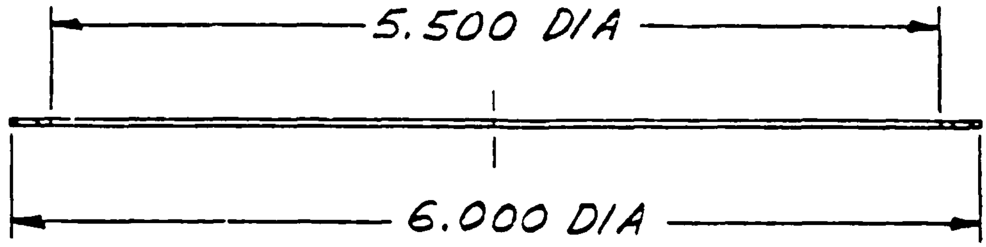
RING, REINFORCING
XK-5 KLYSTRON

ENGR. R. STRINGALL
DFTS. H. GREENHILL
CHK. [illegible]

APPROVALS
10-13-67

PF-700-227-01-R6

A



NOTE:
1. MAT'L: .005 OR .007 MOLYBDENUM
2. CHEMICAL CLEAN BEFORE PUNCHING
3. NEXT ASSY: AD-704-011-00.

UNLESS NOTED
TOLERANCES — BREAK CORNERS .005
FRACT ± 1/64 — INT. RADII .005
DEC ± .005 — 63
ANGLES ± 1/2°

SCALE: 1" = 1"

REV.	DESCRIPTION	DRN.	DATE	APP.	DATE
P3	REDRAWN & NOTE 2 ADDED	H.G.	12-2-69	RJC	12-3-69
R4	CHG. TITLE	H.G.	6-19-70	[illegible]	3-11-70
R5	CHG. TITLE	B.E.	11-[illegible]	[illegible]	11-15-7[illegible]
R6	CHG .007 TO .005 OR .007	S.S.	2-22-80	H.G.	2-22-80
R7	ADDED NOTE 3	J.G.	12-22-83	RTHO	1/11/84

STANFORD LINEAR ACCELERATOR CENTER
U. S. ATOMIC ENERGY COMMISSION
STANFORD UNIVERSITY — STANFORD, CALIFORNIA

SLIP RING
XK-5 KLYSTRON

ENGR R. CALLIN
DFTS H. GREENHILL
CHK [illegible]

APPROVALS
RC [illegible]
12-3-69

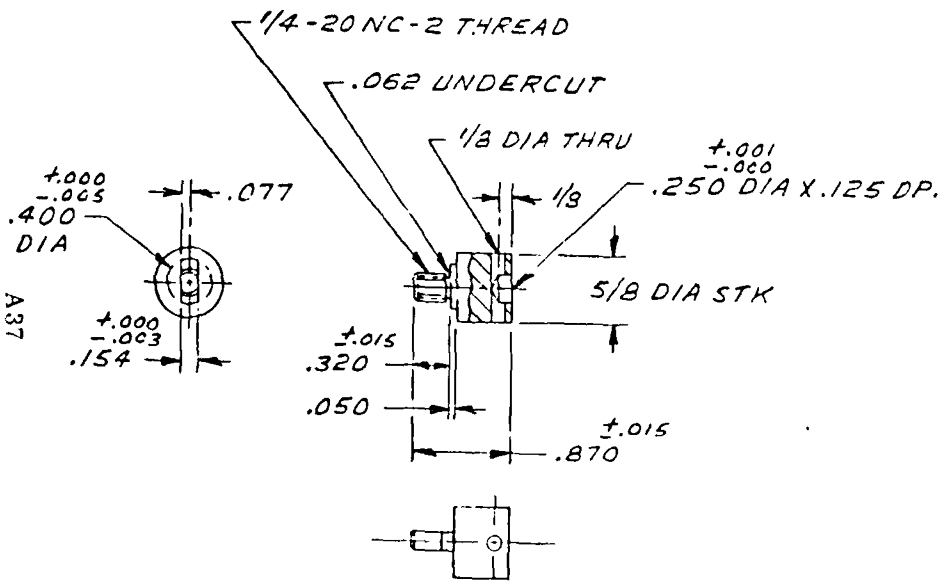
PF-700-228-01-R7 A

12-2-69

MFF7

PF-700-229-01-R9 B

REV.	DESCRIPTION	DRN.	DATE	APP.	DATE
R9	REDRAWN & ADDED NOTE 1.	H.G.	1/15/83	RTB	4/9/84



NOTE:
1. USE ONLY SLAC APPROVED MACHINING FLUIDS PER SC-700-866-47

ITEM NO	PREFIX	BASE	SUFFIX	TITLE OR DESCRIPTION	QTY
—				304 L STN STL	

SCALE: 1" = 1"

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES: BREAK EDGES .005-.015
INTERNAL CORNERS .015 R MAX
FRACTIONS ±
DEC. .X
.XX
.XXX .005
ANGLES ± 1/2° ALL SURFS. 32

DO NOT SCALE DRAWING

STANFORD LINEAR ACCELERATOR CENTER
U.S. DEPARTMENT OF ENERGY
STANFORD UNIVERSITY STANFORD, CALIFORNIA

ENGR
DFTS H. GREENHILL
CHK

APPROVALS

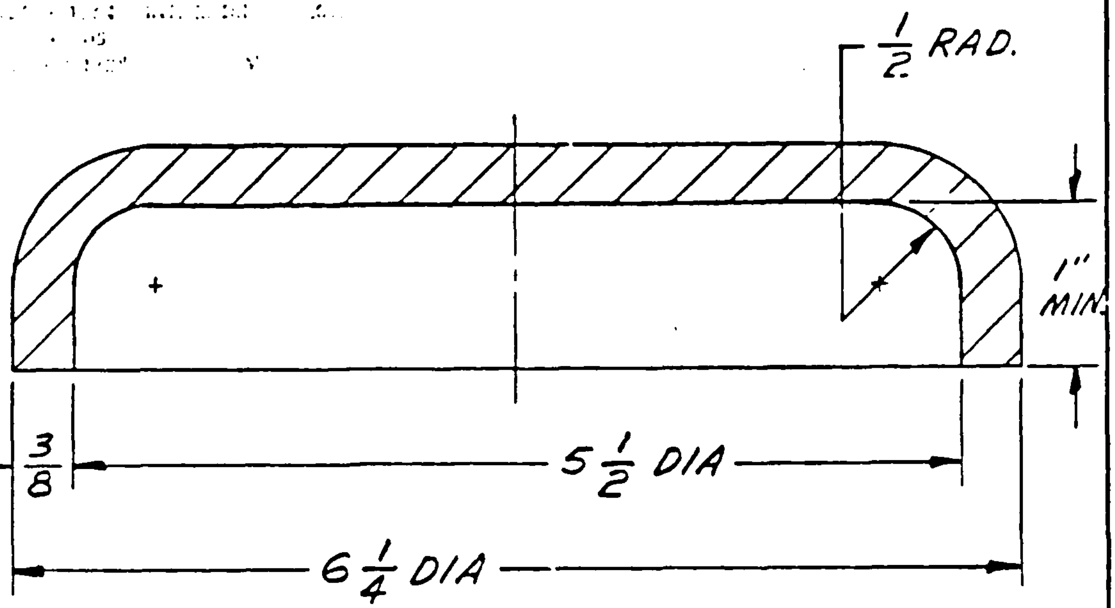
NEXT ASSEMBLY SA-700-783-01

CYLINDER CTR. HEATER XK-5 KLYSTRON

PF-700-229-01-R9 B

SH 1 OF

M/F R9



NOTE:

1. SEE PF-700-288 FOR MACHINING INFORMATION
2. BLANK SIZE = 7 7/8 RD., SAW CUT & MACHINE TO $7.750^{+.000}_{-.015}$
3. ANNEAL AT 750-800°C. FOR 15 MIN. BEFORE FORMING

SCALE: 1" = 1" | MAT'L: 3/8 THK. CERT OFHC CU. PLATE

REV.	DESCRIPTION	DRN.	DATE	APP.	DATE
R2	REDRAWN & NOTES 2 & 3 ADDED	H.G.	7-17-69	[illegible]	[illegible]
R3	CHG. TITLE	H.G.	3-18-70	[illegible]	[illegible]
R4	CHG. TITLE	H.G.	11-15-76	[illegible]	[illegible]
R5	REV. NOTE: 3.	H.G.	10-21-85	[illegible]	[illegible]

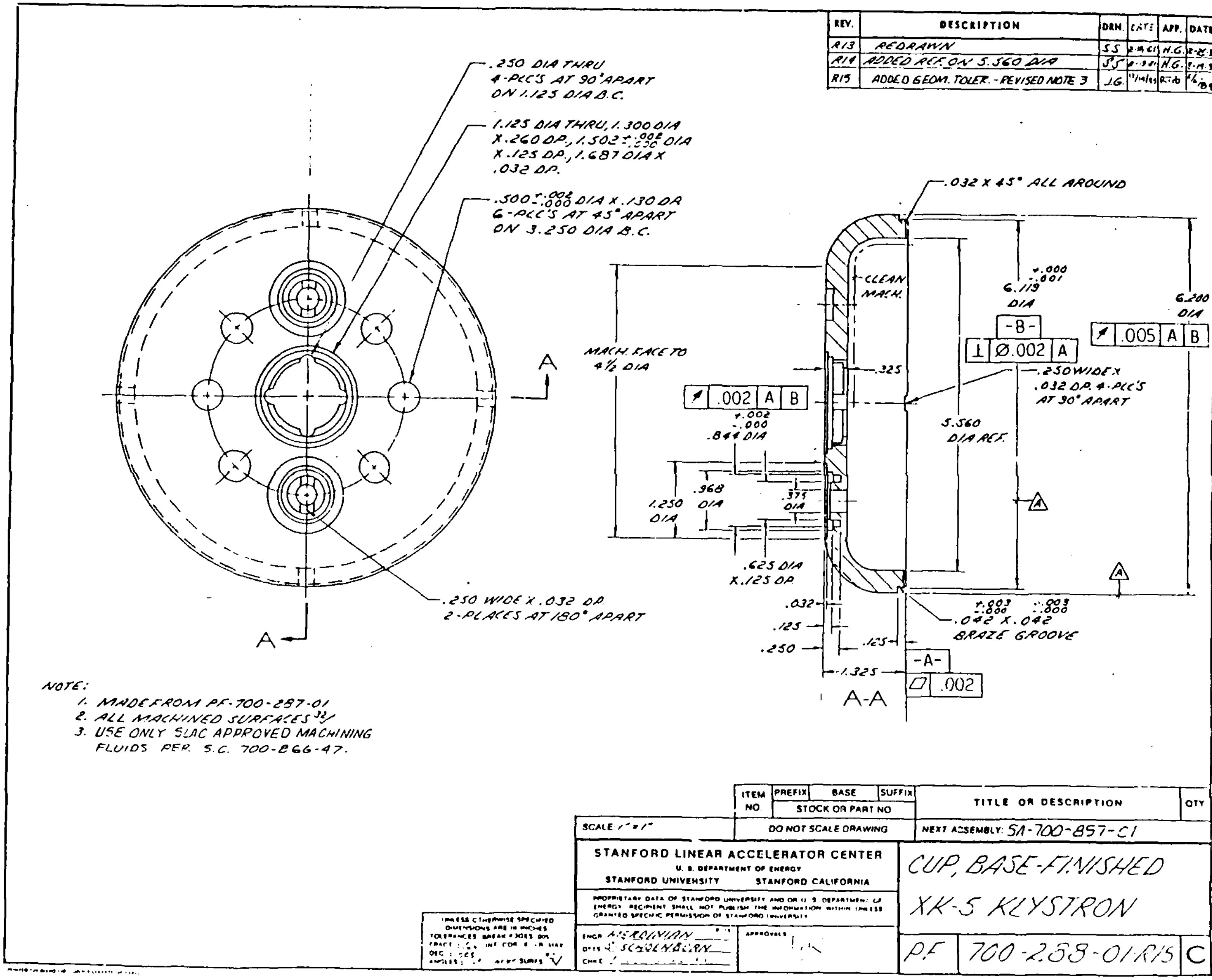
STANFORD LINEAR ACCELERATOR CENTER
U. S. ATOMIC ENERGY COMMISSION
STANFORD UNIVERSITY STANFORD, CALIFORNIA

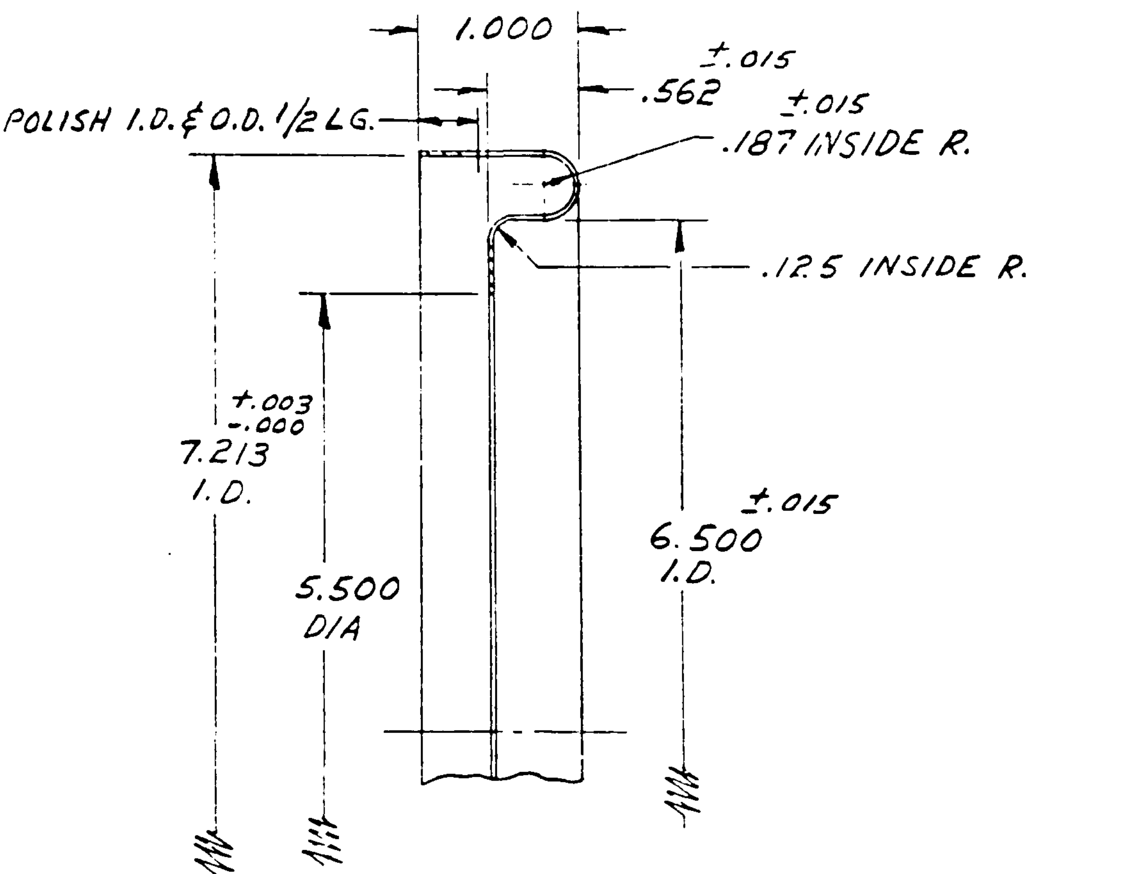
BASE CUP, FORMING
XK-5 KLYSTRON

ENGR. R. CALLIN
DFTS. H. GREENHILL
CHK. [illegible]
APPROVALS [illegible] 7-17-69

PF-700-287-01-R5 | A

MTR5


REV. | DESCRIPTION | DRN. | DATE | APP. | DATE
R13 REDRAWN SS H.G.
R14 ADDED REF. ON 5.560 DIA SS H.G.
R15 ADDED GEOM. TOLER. - REVISED NOTE 3 J.G.
.250 DIA THRU 4-PLC'S AT 90° APART ON 1.125 DIA B.C.
1.125 DIA THRU, 1.300 DIA X .260 DP., 1.502 +.002 -.000 DIA X .125 DP., 1.687 DIA X .032 DP.
.500 +.002 -.000 DIA X .130 DP. 6-PLC'S AT 45° APART ON 3.250 DIA B.C.
.250 WIDE X .032 DP. 2-PLACES AT 180° APART
.032 X 45° ALL AROUND
CLEAN MACH.
MACH. FACE TO 4 1/2 DIA
6.119 +.000 -.001 DIA
-B-
⊥ Ø.002 A
6.200 DIA
.005 A B
.250 WIDE X .032 DP. 4-PLC'S AT 90° APART
5.560 DIA REF.
.002 A B
.844 +.002 -.000 DIA
.325
.968 DIA
1.250 DIA
.375 DIA
.625 DIA X .125 DP.
.042 +.003 -.000 X .042 +.003 -.000 BRAZE GROOVE
.032
.125
.250
.125
1.325
-A-
.002
A-A
A
NOTE:
1. MADE FROM PF-700-287-01
2. ALL MACHINED SURFACES 32
3. USE ONLY SLAC APPROVED MACHINING FLUIDS PER S.C. 700-866-47.
ITEM NO. | PREFIX | BASE | SUFFIX | STOCK OR PART NO
TITLE OR DESCRIPTION | QTY
SCALE 1"=1"
DO NOT SCALE DRAWING
NEXT ASSEMBLY: SA-700-857-C1
STANFORD LINEAR ACCELERATOR CENTER
U. S. DEPARTMENT OF ENERGY
STANFORD UNIVERSITY STANFORD CALIFORNIA
CUP, BASE-FINISHED
XK-5 KLYSTRON
PF 700-288-01-R15 C
PF-700-288-01-R15 C



NOTES:

1. BLANK SIZE = 10 1/3" ROUND BLANK.
2. USE ONLY SLAC APPROVED MACH. FLUIDS PER SC-700-866-47
3. NEXT ASSY: AD-700-650-00.

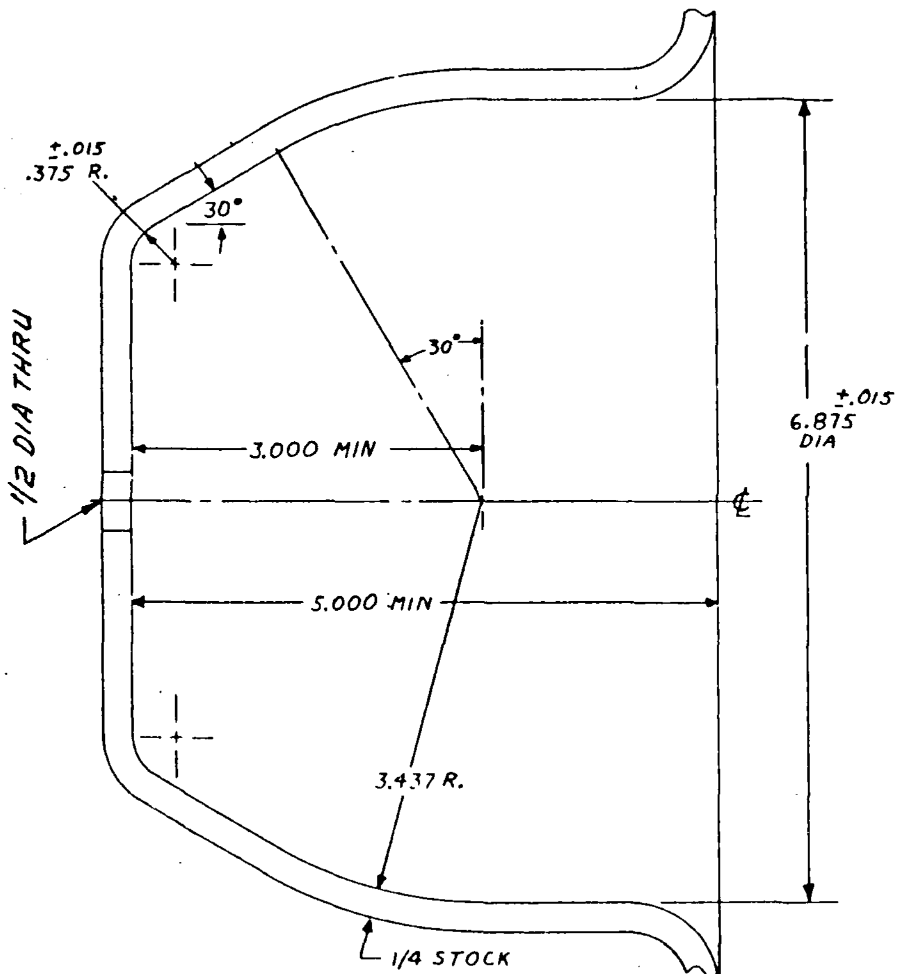
R7	ADDED POLISH NOTE	9-13-78 H.G.	
R6	CHG TITLE	11-25-70	
R5	CHG. TITLE	8-18-70 H.G.	
R4	BLANK SIZE WAS 12" SQ.	12-14-67 H.G.	
R3	[illegible] NOTE [illegible] 3	12-21-67	2-2-64 RTH
R2	DEL. NOTE 2.	12-9-67 H.G.	
R1	ADDED NOTE 2.	9-17-79 H.G.	

UNLESS NOTED
TOLERANCES [illegible]
63

STANFORD LINEAR ACCELERATOR—M U.S. ATOMIC ENERGY COMMISSION	TITLE TAKE-APART JOINT-OUTER XK-5 KLYSTRON
MAT'L. .062 THK. 70-30 CUPRO-NI	
ENGR. [illegible] CHK'D [illegible]	DATE 10-10-62
DFTS. [illegible] HILL APPV'D [illegible]	SCALE 1"=1" — PF-700-297-01-R10

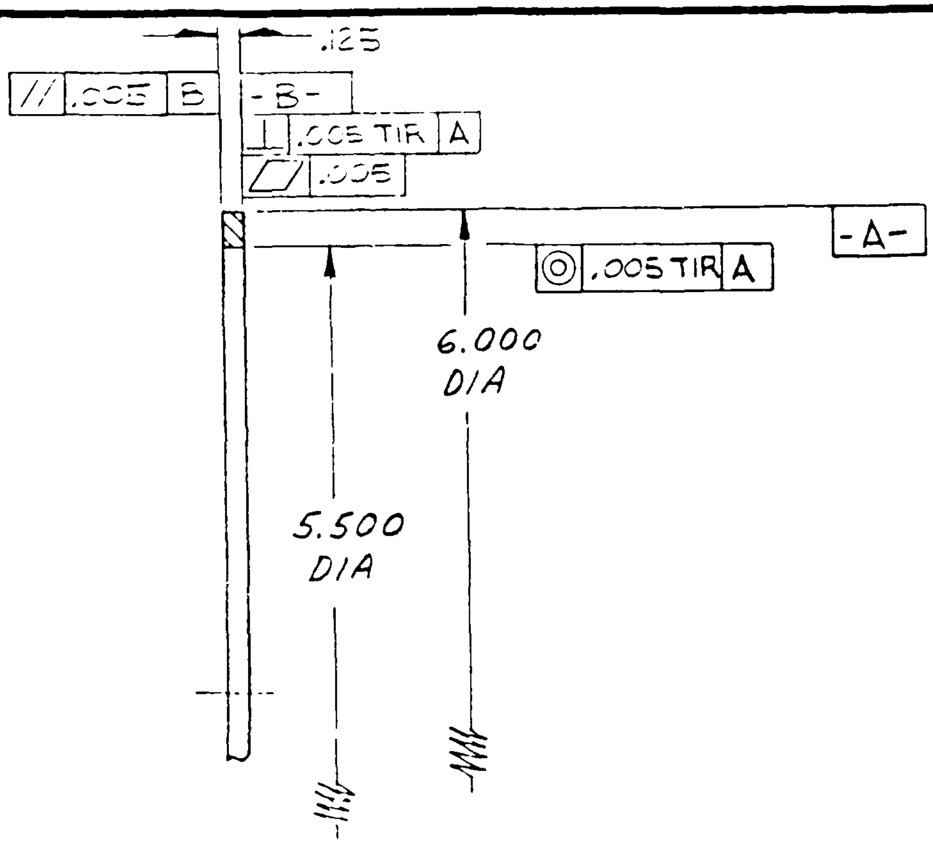
PF-700-301-01-R10 B

REV	DESCRIPTION	DRN	DATE	APP	DATE
R10	WAS MP-700-301-01, ADDED SPECS	H.G.	[illegible]	[illegible]	[illegible]



NOTE:
1. MAT'L: #304 STN STL, BLANK SIZE = 16" SQ.
2. STRESS RELIEVE AT 950° - 1000°C. FOR 10-20 MIN., WITH FAST COOL

SCALE: 1" = 1"	DO NOT SCALE DRAWING	NEXT ASSEMBLY:
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES BREAK EDGES .005 FRACT ± 1/64 DEC ± .005 ANGLES ± 1/2	STANFORD LINEAR ACCELERATOR CENTER U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION STANFORD UNIVERSITY STANFORD, CALIFORNIA ENGR G. KONRAD DES H. GREENHILL CHK H.G. 7-21-77 APPROVALS	ANODE HOUSING BLANK XK-5 KLYSTRON PF-700-301-03-R10 B



NOTES:

1. MADE FOR PF-700-862-04

PF-700-648

R5	ADD GEOM. TOL.	2-21-83 HW	2-2-84 RHD
R4	CHG TITLE	11-23-76 E.E.	
R3	CHG. TITLE	8-18-70 H.G.	R.C.
R2	CHANGED TITLE	5-6-65 H.G.	R.E.B.
R1	TITLE WAS: RING, SLIP	11-14-63 H.G.	

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES.
TOLERANCES: BREAK EDGES .005
FRACT ± 1/64 INT COR .005 R MAX
DEC. ± .005
ANGLES ± 1/2° ALL SURFS.

STANFORD LINEAR ACCELERATOR—M
U.S. ATOMIC ENERGY COMMISSION

MAT'L. CERAMIC - AL-300

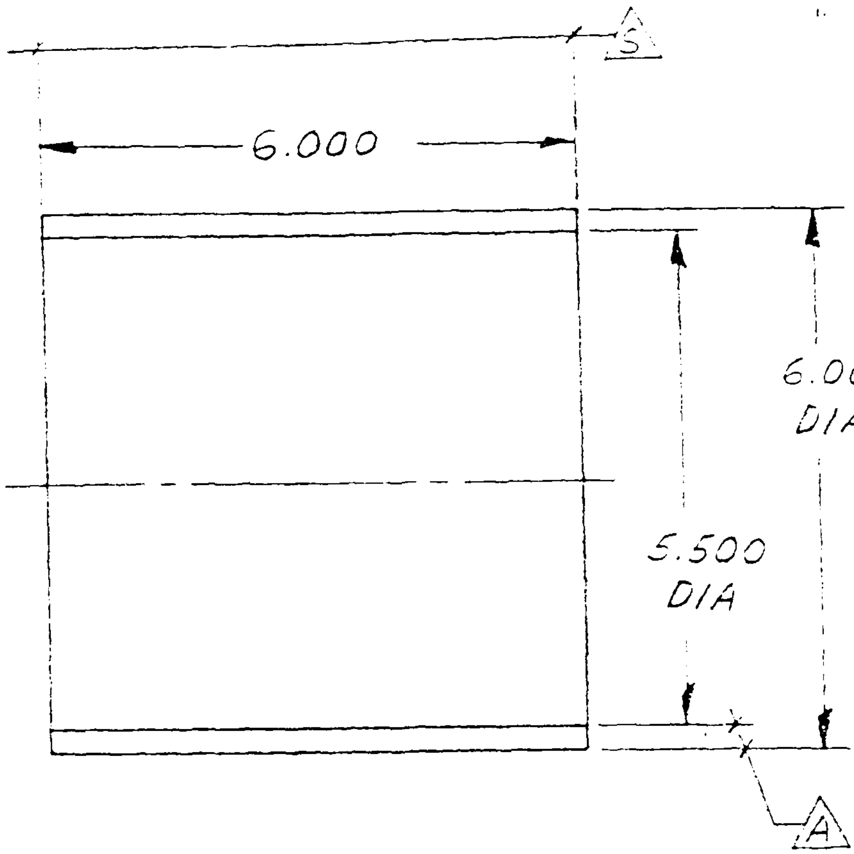
ENGR. [illegible] CHK'D [illegible]
DFTS. GREENHILL 2-6-63 APPV'D [illegible]

TITLE RING, BACK UP
XK-5 KLYSTRON

DATE 2-6-63
SCALE 1"=1"

PF-700-648-01-R5

MF R5



NOTE

1. TWO DIA'S. A TO BE CONC. WITHIN .005 T.I.R.
2. TWO SURFACES S TO BE FLAT, PARALLEL TO EACH OTHER & PERPENDICULAR TO ℄ WITHIN .005 T.I.R.

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES.
TOLERANCES: BREAK EDGES .005-.015
FRACT. ± 1/64 INT. COR. .015 R. MAX.
DEC. ± .005
ANGLES ± 1/2° ALL SURFS.

R3	CHG TITLE	4-23-76 B.E.	[illegible]
R2	CHG. TITLE	8-18-70 H.G.	[illegible]
R1	CHANGED TITLE	5-6-65 H.G.	R.E.B.

STANFORD LINEAR ACCELERATOR—M
U.S. ATOMIC ENERGY COMMISSION

MAT'L. CERAMIC - AL-300

ENGR. MERVINIAN CHK'D H.G.
DFTS. GREENHILL 2-6-63 APPV'D [illegible]

TITLE CERAMIC XK-5 KLYSTRON

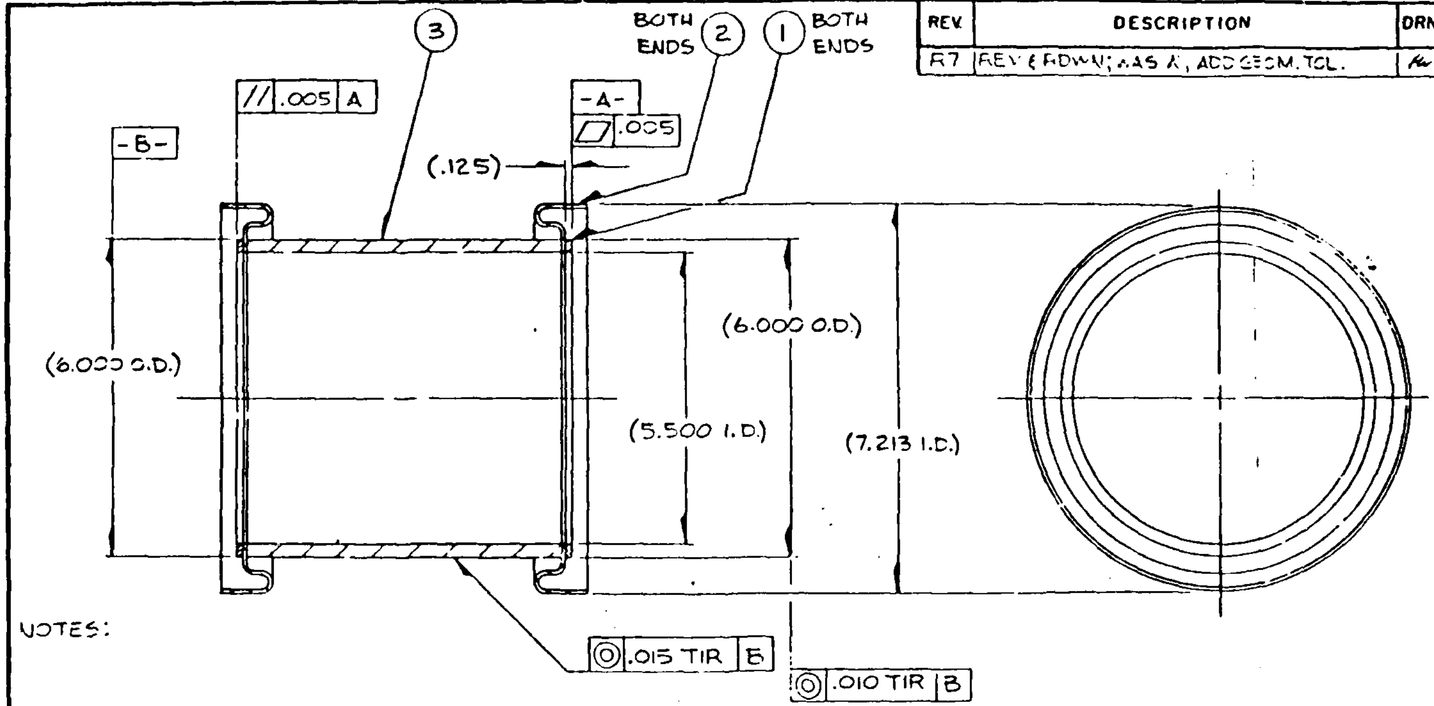
DATE 2-6-63
SCALE 1/2" = 1"

PF-700-649-01-R3

PF-700-649

B | PF-700-650-00-R7

REV	DESCRIPTION	DRN.	CHK	APP.	DATE
R7	REV & RDWN; WAS A, ADD GEOM. TOL.				



NOTES:

ITEM NO	PREFIX	BASE	SUFFIX	TITLE OR DESCRIPTION	QTY
3	PF	700-362	05	CERAMIC, PLATED	1
2	PF	700-297	01	TAKE-APART JOINT, OUTER	2
1	PF	700-922	04	RING FL- BACK UP	2
	STOCK OR PART NO				

SCALE: 1/2

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES: BREAK EDGES .005-.015
INTERNAL CORNERS .015 R MAX
FRACTIONS
DEC.
ANGLES
ALL SURFS.

DO NOT SCALE DRAWING

STANFORD LINEAR ACCELERATOR CENTER
U.S. DEPARTMENT OF ENERGY
STANFORD UNIVERSITY STANFORD, CALIFORNIA

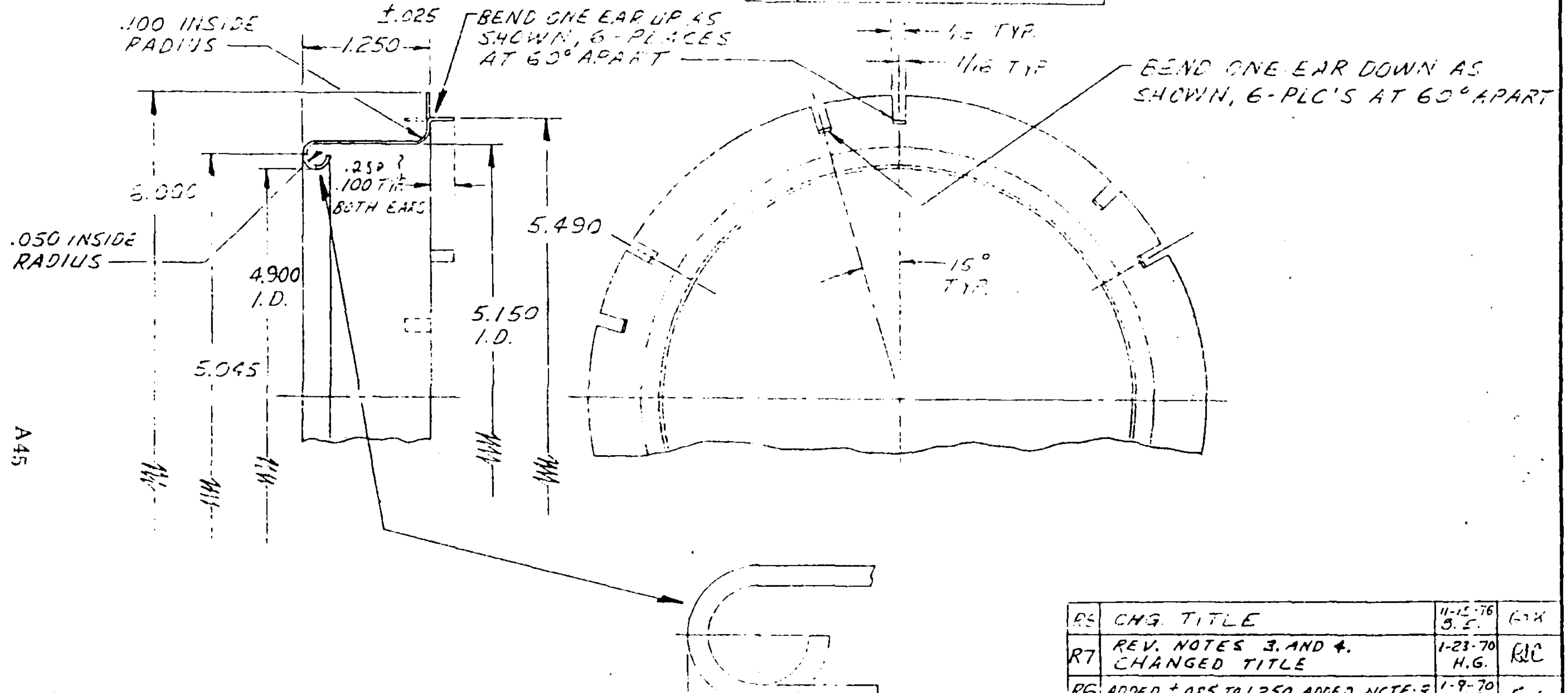
NEXT ASSEMBLY

ASSY, SEAL-CERAMIC
XK-5 KLYSTRON

AD-700-650-00-R7 | B

SH 1 OF 1

M/F



NOTE:
1. MAT'L: .020 THK. ELECT. GRADE 'A' NICKEL
2. BLANK SIZE = 8 1/4" SQ. OR 8" RD.
3. ANNEAL BLANK AT 700° C. FOR 5-MIN.
4. AFTER FORMING AND SLITTING EARS, POLISH BEFORE ANNEALING AT [illegible] °C. FOR 10-MIN. (DO NOT BEND EARS UNTIL AFTER ANNEALING)

R8	CHG. TITLE	11-15-76 B.E.	[illegible]
R7	REV. NOTES 3. AND 4. CHANGED TITLE	1-23-70 H.G.	RJC
R6	ADDED ±.025 TO 1.250, ADDED NOTE: 3.	1-9-70 H.G.	[illegible]
R5	MAT'L WAS CERT. OFHC COPPER	[illegible] H.G.	[illegible]
R4	1/16 WAS 1/8, 1/8 WAS 1/4 CHG. EAR BEND DET. AS SHOWN	[illegible] H.G.	[illegible]
R3	CHANGED TITLE	5-8-65 H.G.	R.E.E.
R2	ADDED BLOW-UP DETAIL & NOTES	12-11-64 H.G.	[illegible]
R1	.050 INSIDE R. WAS .100 R. [illegible] 4.900 I.D. WAS 4.700	[illegible]	[illegible]

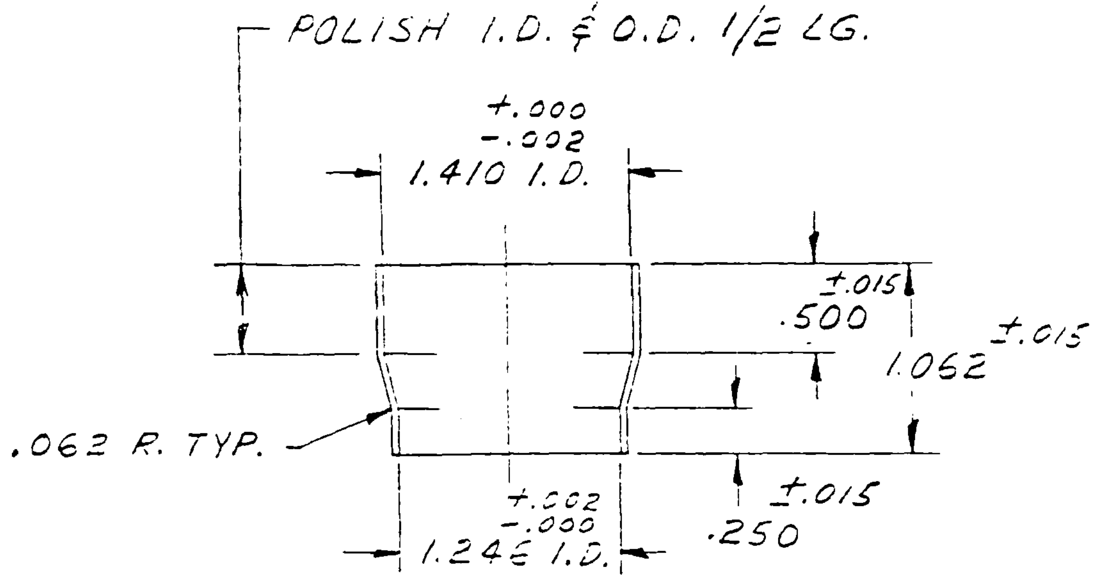
STANFORD LINEAR ACCELERATOR CENTER
U.S. ATOMIC ENERGY COMMISSION

TITLE RING, CORONA XK-1 KLYSTRON

ENGR. MERDINIAN CHK'D [illegible]
DFTS GREENHILL APP'D

DATE [illegible]-63 SCALE [illegible]

PF-700-652-01-F B



NOTE:

1. MAT'L: .020 THK. 70-30 CUPRO-NICKEL
2. BLANK SIZE = 3.010 DIA
3. CHEMICAL CLEAN
4. ANNEAL AT 800 - 850° C. FOR 20 MIN. BEFORE DRAWING
5. CHEMICAL CLEAN
6. STRESS RELIEVE AT 800°-850° C. FOR 20 MIN. BEFORE MACHINING

13 SEP 1979

PF-700-654

R5	REV. NOTES	7-16-71 H.G.	[illegible]
R4	DEL. NOTES 5. & 6. CHANGED TITLE	1-23-70 H.G.	RC
R3	REVISED NOTES	7-17-69 H.G.	RC
R7	ADDED POLISH NOTE	9-13-78 H.G.	[illegible]
R6	CHANGED TITLE	[illegible]	[illegible]

UNLESS NOTED

TOLERANCES		BREAK CORNER	.005
FRACT.	± 1/64	INT. RADII	.015
DEC.	± .005		63
ANGLES	± 1/2°		

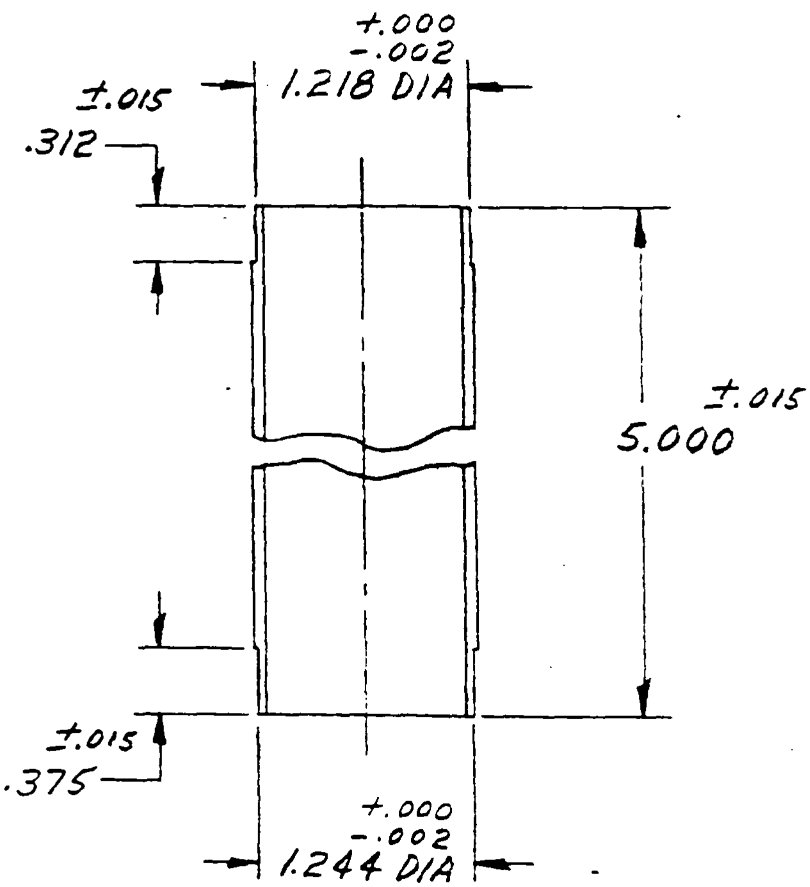
STANFORD LINEAR ACCELERATOR—M
U.S. ATOMIC ENERGY COMMISSION

TITLE CUP, SEALING-MALE XK-5 KLYSTRON

ENGR. MERDINIAN CHK'D H.G.
DFTS. GREENHILL 3-12-63 APPV'D [illegible]

DATE 3-12-63
SCALE 1" = 1"

PF-700-654-01-R7



NOTE:
1. MACHINED SURFACES $\overset{32}{\vee}$
2. POLISH STOCK O.D

5	ADDED NOTE # 2.	9-4-80 S.S.	[illegible]
4	DEL. BRZ. GROOVES	3-21-80 S.S.	H.G. 3-21-80
R3	CHG. TITLE	11-23-76 B.E.	[illegible] 11-23-76
R2	CHG. TITLE	8-18-70 H.G.	[illegible]
R1	CHANGED TITLE	5-6-65 H.G.	R.E.B.

UNLESS NOTED
TOLERANCES — BREAK CORNER .005
FRACT ± 1/64 — INT. RADII .015
DEC. ± .005
ANGLES ± 1/2° — $\overset{63}{\vee}$

STANFORD LINEAR ACCELERATOR—M
U.S. ATOMIC ENERGY COMMISSION

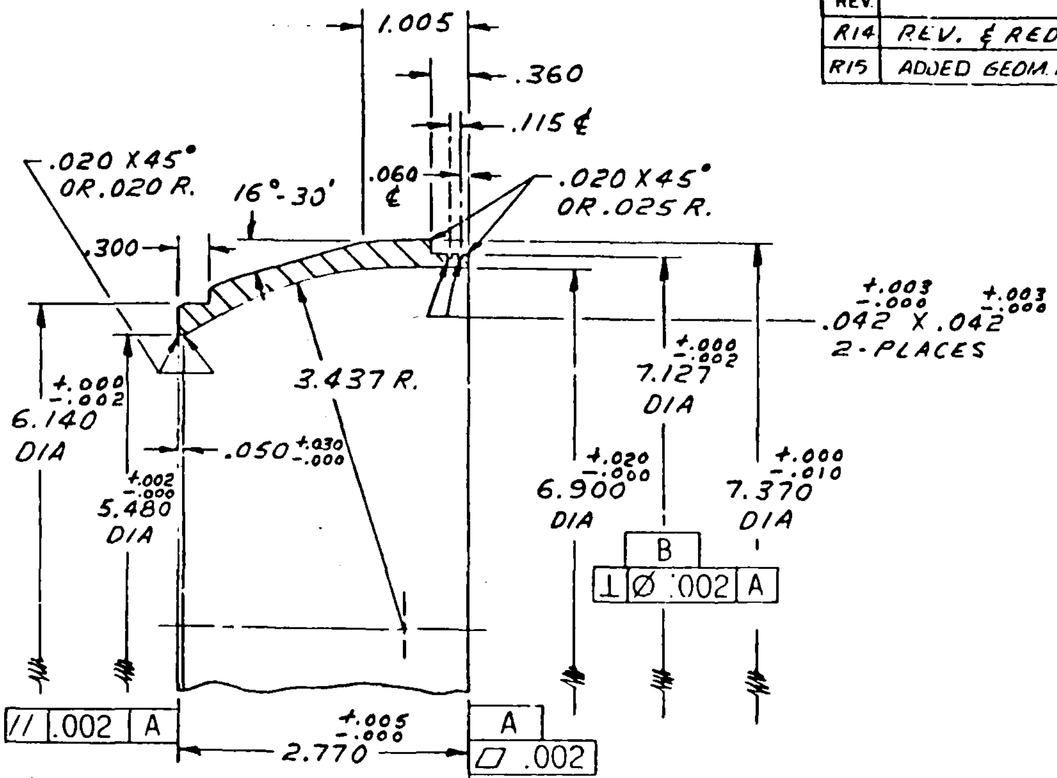
MAT'L. 1 1/4 O.D. X 1/16 W. CERT. O.F.H.C. CU

ENGR. MERDINIAN — CHK'D H.G.
DFTS GREENHILL 3-8-63 — APPV'D [illegible]

TITLE TUBE, PUMPOUT XK-5 KLYSTRON

DATE 3-12-63
SCALE 1" = 1"

PF-700-655-01-R5



B	PF-700-682-01-R15				
REV.	DESCRIPTION	DRN.	DATE	APP	DATE
R14	REV. ¢ REDRAWN	H.G.	4-6-85	UC	
R15	ADDED GEOM. TCLER - REV. NOTE 3	J.G.	12/7/84	RTB	2/4/5

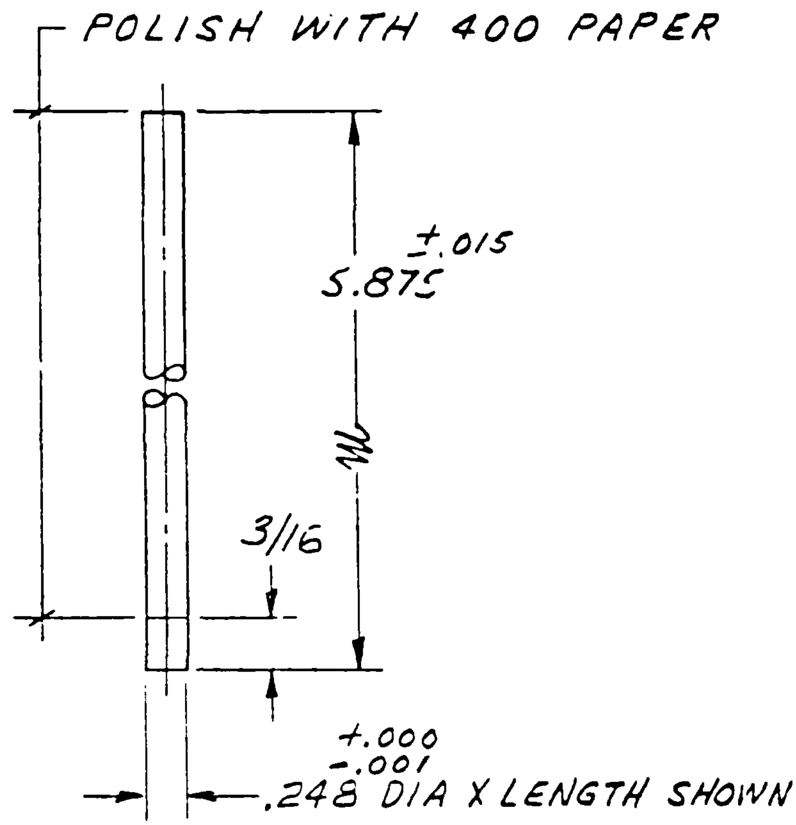
NOTE:

1. MADE FROM PF-700-301-03
2. STRESS RELIEVE AT 550-1000°C. FOR 10-20 MIN. WITH FAST COOL
3. USE ONLY SLAC APPROVED MACHINING FLUID PER SC-700-866-47

ITEM NO	PREFIX	BASE	SUFFIX	TITLE OR DESCRIPTION	QTY
	STOCK OR PART NO				

SCALE 1" = 1"	DO NOT SCALE DRAWING	NEXT ASSEMBLY: SA-700-770-01
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES BREAK EDGES .005 MAX FRACT : INT COR .015 R MAX DEC : .005 ANGLES : ALL SURFS 63✓	STANFORD LINEAR ACCELERATOR CENTER U.S. DEPARTMENT OF ENERGY STANFORD UNIVERSITY STANFORD CALIFORNIA ENGR R. SCESENBERG DFTR H. GREENHILL CHK APPROVALS	HOUSING, ANODE XK-5 KLYSTRON
		PF-700-682-01-R15 B

MFR15



NOTE:
1. MAT'L: 1/4 DIA 304 L STN STL ROD
2. USE ONLY SLAC APPROVED MACHINING FLUIDS PER SC-700-866-47
3. NEXT ASSY: SA-700-783-01

R6	3/16 WAS 5/16 & 5.875 WAS 6.000	3-21-80 S.S.	3-21-80 H.G.
R5	ADDED POLISH NOTE	2-1-80 H.G.	[illegible]
R4	CHG. TITLE	11-15-76 B.E.	[illegible]
R3	ADDED .248 DIA X 5/16 LG.	5-28-71 H.G.	[illegible]
R2	CHG. TITLE	6-18-70 H.G.	[illegible]
R7	ADDED NOTES 2 & 3	12-14-83 H.G.	[illegible]

UNLESS NOTED
TOLERANCES — BREAK CORNER .005
FRACT. ± 1/64 — INT. RADII .01
DEC ± .005
ANGLES ± 1/2° — 32 MACH. SURF'S

STANFORD LINEAR ACCELERATOR
U.S. ATOMIC ENERGY COMMISSION

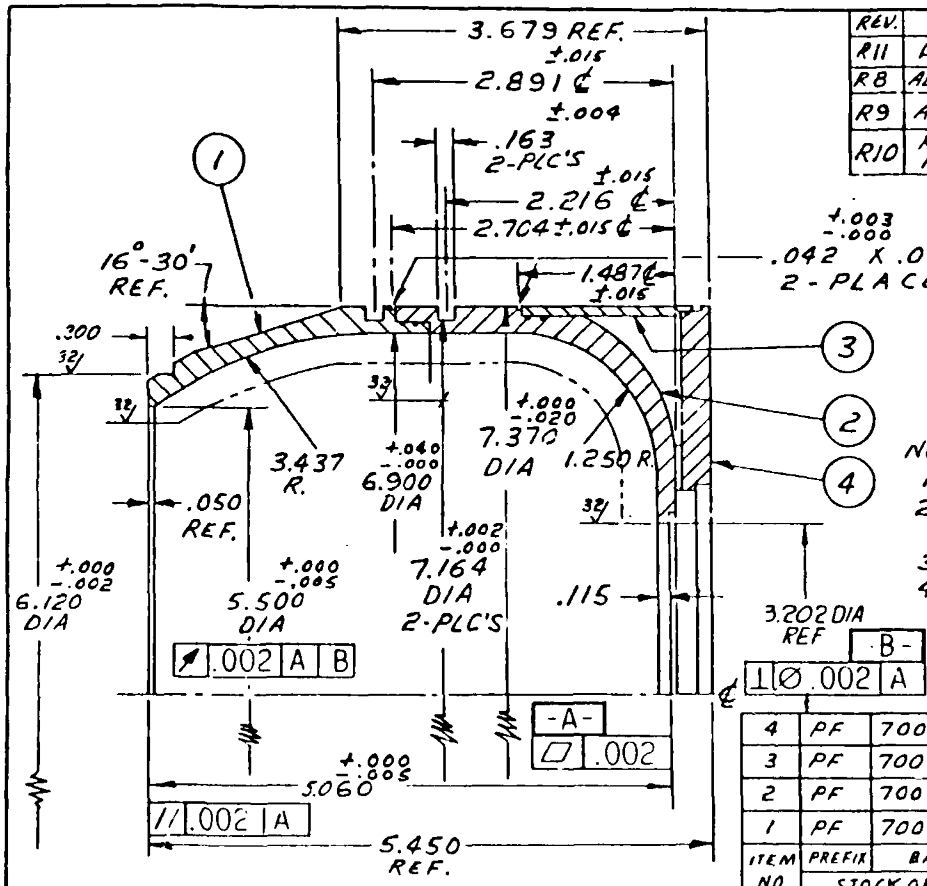
TITLE ROD. CENTER HEATER XK-5 KLYSTRON

ENGR G. [illegible] CHK'D [illegible]
DFTS H. GREENHILL 2-2-66 APPV'D [illegible]
DATE 2-22-66
SCALE 1" = 1"

PF-700-759-01-R7

SA-700-770-01-R11 B

REV.	DESCRIPTION	DRN	DATE	APP.	DATE
R11	ADDED GEOM TOLER-NOTE 4	J.G.	12-4-85	RTH	[illegible]
R8	ADDED 5.500 DIA & .300 & 5.044 REF.	S S	1-22-80	H.G.	1-22-80
R9	ADDED 6.120 DIA	H.G	9-29-80	[illegible]	[illegible]
R10	REV. & CHANGED SEVERAL DIM'S PER MACH SPEC'S	H.G.	6-4-82	[illegible]	[illegible]



NOTE:
1. MACHINE AS NOTED
2. MACHINE INSIDE 32 AS SHOWN, POLISH OUT ALL SCRATCHES
3. USE O-RING SIZE 7 X 7 1/4 X 1/8 NOM.
4. USE ONLY SLAC APPROVED MACHINING FLUIDS PER SC-700-866-47.

ITEM NO.	PREFIX	BASE	SUFFIX	TITLE OR DESCRIPTION	QTY.
4	PF	700-729	01	PLATE, INPUT A	1
3	PF	700-673	01	CYLINDER, ANODE	1
2	PF	700-663	02	CUP, ANODE	1
1	PF	700-682	01	HOUSING, ANODE	1
	STOCK OR PART NO.				

SCALE: 1" = 1"

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES BREAK EDGES .005 MAX
FRACT ± 1/64
DEC ± .005
ANGLES ± 1/2°

DO NOT SCALE DRAWING

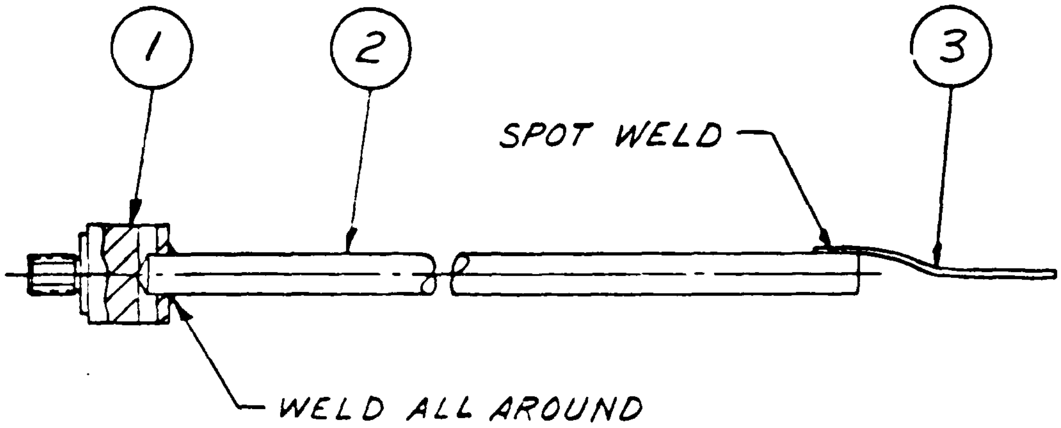
STANFORD LINEAR ACCELERATOR CENTER
U. S. ATOMIC ENERGY COMMISSION
STANFORD UNIVERSITY STANFORD CALIFORNIA

H. GREENWELL

NEXT ASSEMBLY: SA-700-857-02

ASSY, ANODE SHELL (MACH)
XK-5 KLYSTRON

SA-700-770-01-R11 B



NOTE:
1. NEXT ASSY: SA-700-786-01

ITEM NO.	PREFIX	BASE	SUFF.	DESCRIPTION	QTY.
3				.005 THK. X .300 X 1.5 LG. NICKEL STRIP	4
2	PF	700-759	01	ROD, CENTER HEATER	1
1	PF	700-229	01	CYLINDER	1

REV.	DESCRIPTION	DRN.	DATE	APP.	DATE
R1	CHG. TITLE	H.G.	8-19-70	[illegible]	[illegible]
R2	CHG. TITLE	B.E.	11-5-70	LTK	11-15-76
R3	.300 WAS .287	B S	6-12-79	H.G	6-11-79
R4	ADDED NOTE 1.	H.G.	12/14/83	RTH	2/3/84

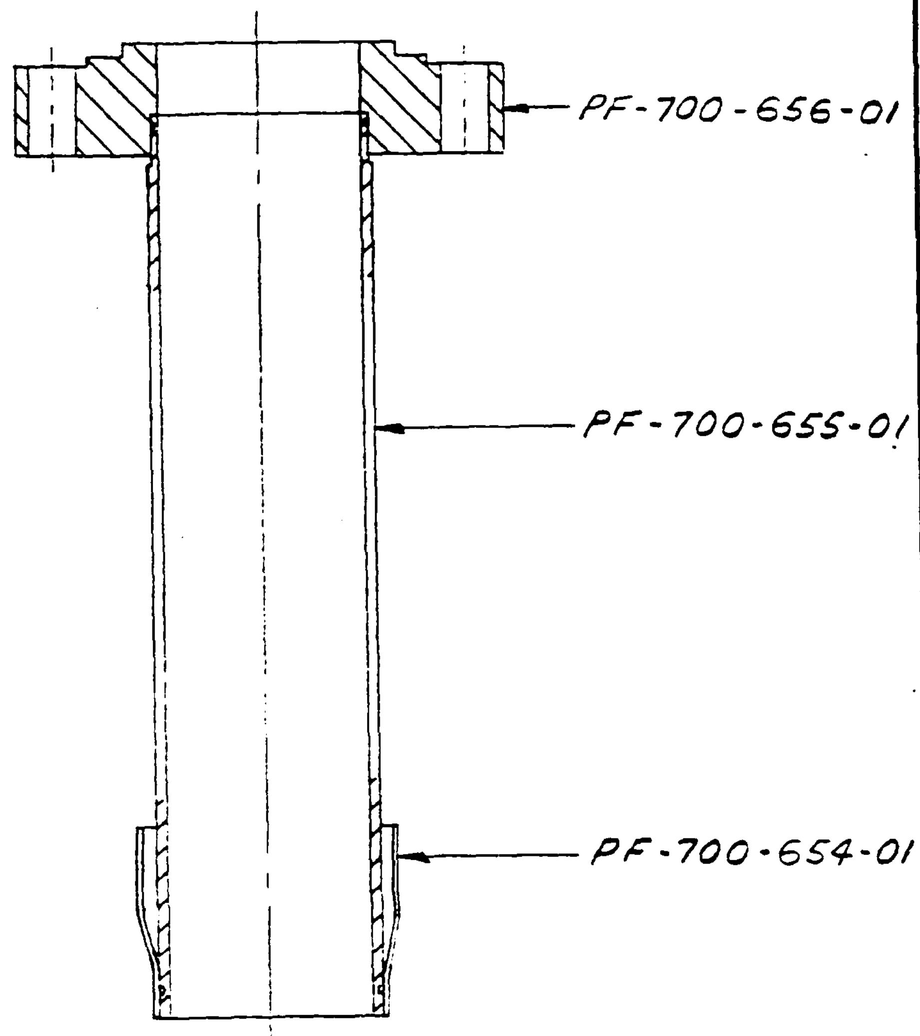
STANFORD LINEAR ACCELERATOR CENTER
U. S. ATOMIC ENERGY COMMISSION
STANFORD UNIVERSITY STANFORD, CALIFORNIA

ENGR. R. CALLIN
DFTS. H. GREENHILL
CHK [illegible]

APPROVALS
1-3-69

ASM. CTR. HEATER COND.
XK-5 KLYSTRON

SA-700-783-01-R4 A

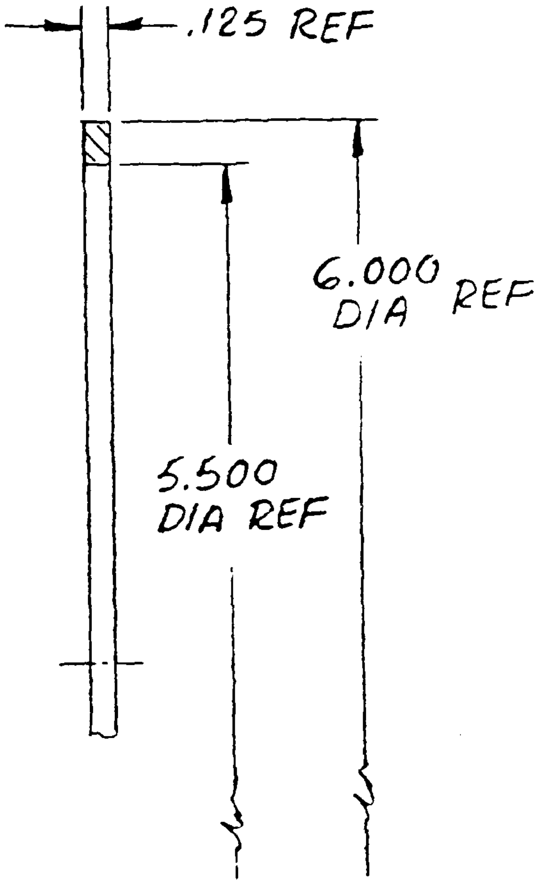


SCALE: 1" = 1"

REV.	DESCRIPTION	DRN.	DATE	APP.	DATE

14 JUL 1978

STANFORD LINEAR ACCELERATOR CENTER U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION STANFORD UNIVERSITY STANFORD CALIFORNIA	ASSY, PUMPOUT XK-5 KLYSTRON	
ENGR G. KONRAD DFTS H. GREENHILL CHK. CPA 7-13-78 — APPROVALS	SA-700-857-17-R0	A



NOTE:
1. MADE FROM PF-700-648-01
2. OFHC Cu. PLATE 0.0002 ALL METALLIZED SURFACES.

SCALE: 1"=1"

REV.	DESCRIPTION	DRN.	DATE	APP.	DATE

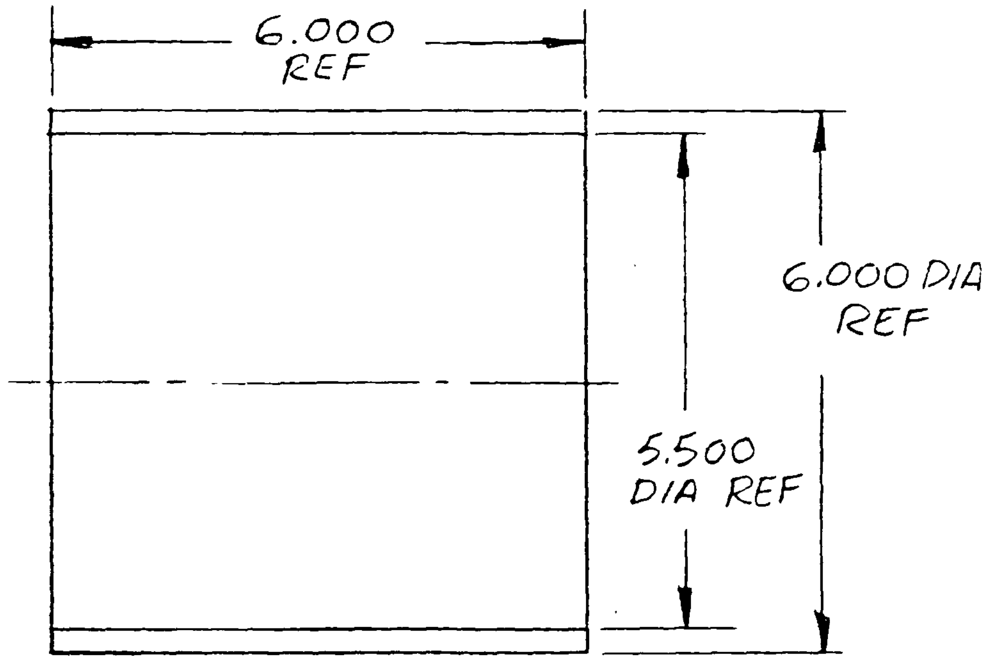
STANFORD LINEAR ACCELERATOR CENTER
U S DEPARTMENT OF ENERGY
STANFORD UNIVERSITY STANFORD, CALIFORNIA

ENGR R. BOESENBERG
DFTS M. WALLACE
CHK H. G.

APPROVALS
2-24-82

RING, PL - BACK UP
XK-5 KLYSTRON

PF-700-862-04-R0 | A



NOTE:

1. MADE FROM PF-700-649-01
2. OFHC Cu. PLATE 0.0002 ALL METALLIZED SURFACES

SCALE: 1/2" = 1"

REV.	DESCRIPTION	DRN.	DATE	APP.	DATE

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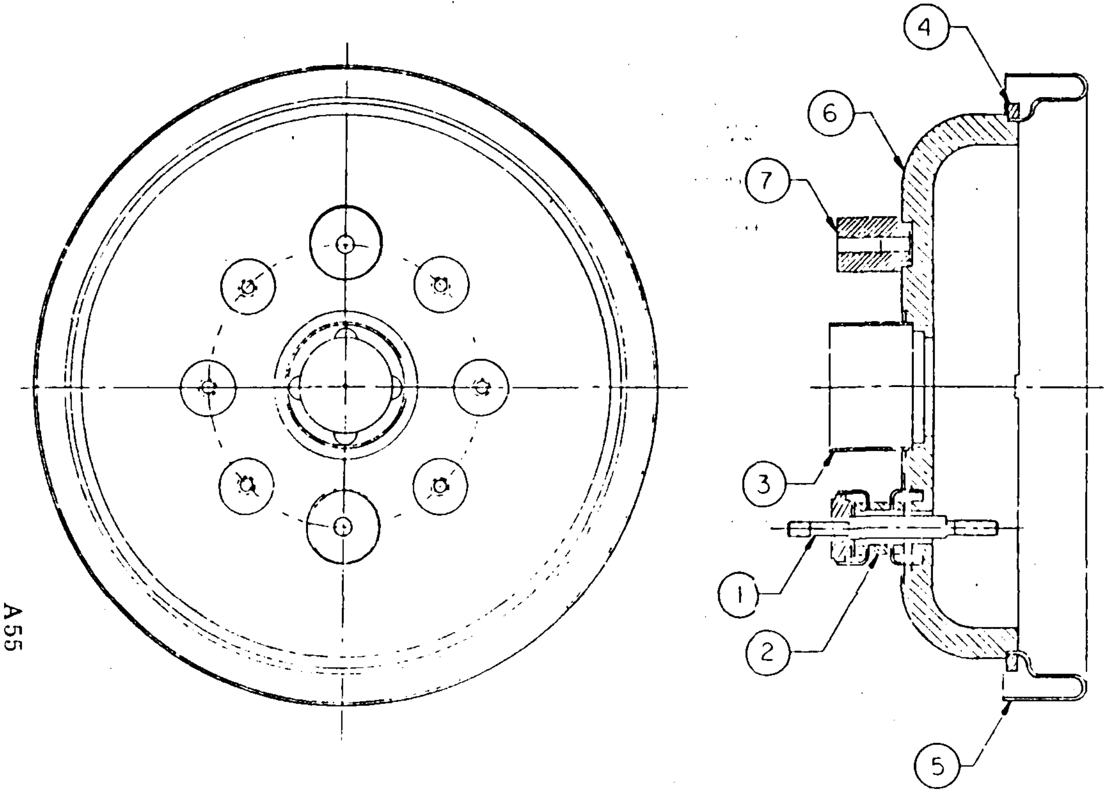
DFTS M. WALLACE
CHK H. G.

APPROVALS
2-24-82

CERAMIC, PLATED
XK-5 KLYSTRON

PF-700-862-05-R0 A

REV.	DESCRIPTION	DRN.	DATE	APP.	DATE
R1	REDRAWN WITH PARTS LIST - SAME DWG NO.	JG	11 Mar 93	R.T.V.S.	2/4/93



NOTE:
1. ALL BRAZING TO BE NICORO.

ITEM NO.	PREFIX	BASE	SUFFIX	TITLE OR DESCRIPTION	QTY.
7	PF	700-635	01	CATHODE STUD	6
6	PF	700-288	01	CUP BASE - FINISHED	1
5	PF	700-236	01	TAKE APART JOINT	1
4	PF	700-227	01	RING, REINFORCING	1
3	PF	700-224	01	SEALING RING - P.O.T. - FEMALE	1
2	SA	700-851	74	ASSEMBLY CUPS AND INSULATORS	2
1	SA	700-851	73	ASSEMBLY ROD-CYLINDER-FEED THRU	2
	STOCK OR PART NO.				

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES:
BREAK EDGES .005-.015
INTERNAL CORNERS .015 R MAX
FRACTIONS ±
DEC .X
.XX
.XXX
ANGLES ± ALL SURFS √

SCALE: 1/1

DO NOT SCALE DRAWING

NEXT ASSEMBLY: AD-704-011-00

STANFORD LINEAR ACCELERATOR CENTER
U.S. DEPARTMENT OF ENERGY
STANFORD UNIVERSITY STANFORD, CALIFORNIA

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ENGR T.L.L.
DFTS J. GIANELLI
CHKD
DATE
APPROVALS
JL 1/11/94

ASSEMBLY, BASE CUP
XK-5 KLYSTRON

SA | 700-857-01-R1 | C

SH 1 OF 1

M/F

SA-700-857-01-R1 | C

APPENDIX A-4

PARTS AND MATERIALS LIST

10 FIN-RA001 ALDAMA ENGINEERING INDENTED EXPLOSION FEB 6, 1986 MDAY 793 PAGE 1

REQUEST UNIT CODE 01 PART NUMBER 00-192143-00 REV C DESCRIPTION NRL GUN ASSY K9025 QTY 1

*** LOW LEVEL *****	UC	S Z	PART NUMBER	DW RV	OS RV	DESCRIPTION	UI	QUANTITY PER ASSY (PS DATA)	TOTAL QUANTITY	E M	WK CTR	ENGNR CHG	EFFDT/SRL START	STOP	K	OPN NR (ITEM)	TSD	LT	CUM LT	RIF	F M
1	01	A	27-402483-00	TT		O RING CRANE 1820-67	EA	1.0000	1.000	0		AUDIT	00000	00000	0	000	000	000	000	1.00	
1	01	B	00-192192-00	*		ANODE & CONFLAT ASSY	EA	1.0000	1.000	0		AUDIT	00000	00000	0	000	100	000	000	1.00	
.2	01	C	00-192193-00	*		ANODE ASSY MACH	EA	1.0000	1.000	0		AUDIT	00000	00000	0	000	100	000	000	1.00	
..3	01	D	00-192194-00	*		ANODE	EA	1.0000	1.000	0		AUDIT	00000	00000	0	000	200	000	000	1.00	
..3	01	A	00-192195-00	*		CONFLAT ADPTR SLEEVE	EA	1.0000	1.000	0		AUDIT	00000	00000	0	000	200	000	000	1.00	
..3	01	C	00-192196-00	*		ANODE JACKET	EA	1.0000	1.000	0		AUDIT	00000	00000	0	000	200	000	000	1.00	
..3	01	A	00-192197-00	*		COOLANT FITTING	EA	2.0000	2.000	0		AUDIT	00000	00000	0	000	200	000	000	1.00	
1	01	C	00-192198-00	*		HOUS SEAL RING ASSY	EA	1.0000	1.000	0		AUDIT	00000	00000	0	000	100	000	000	1.00	
.2	01	C	00-192199-00	*		ANODE HOUSING ASSY	EA	1.0000	1.000	0		AUDIT	00000	00000	0	000	100	000	000	1.00	
.2	01	C	00-192201-00	*		WELD RING A	EA	1.0000	1.000	0		AUDIT	00000	00000	0	000	200	000	000	1.00	
1	01	C	00-192200-00	*		IRON HOUSING ASSY	EA	1.0000	1.000	0		AUDIT	00000	00000	0	000	100	000	000	1.00	
.2	01	C	00-192202-00	*		WELD RING B	EA	1.0000	1.000	0		AUDIT	00000	00000	0	000	200	000	000	1.00	
.2	01	C	00-192203-00	*		WELD RING C	EA	1.0000	1.000	0		AUDIT	00000	00000	0	000	200	000	000	1.00	
.2	01	D	00-192204-00	*		IRON HOUSING	EA	1.0000	1.000	0		AUDIT	00000	00000	0	000	200	000	000	1.00	
1	01	B	00-192207-00	*		GUN COIL	EA	1.0000	1.000	0		AUDIT	00000	00000	0	000	200	000	000	1.00	
.2	01	C	00-192206-00	*		BOBBIN	EA	1.0000	1.000	0		AUDIT	00000	00000	0	000	200	000	000	1.00	
.2	01		12-312006-08	TT		6-32 X 1/2 SCHCSCR	EA	6.0000	6.000	0		AUDIT	00000	00000	0	000	100	000	000	1.00	
.2	01	A	81-101918-00	TT		18AWG MAGNET WIRE	EA	1.0000	1.000	0		AUDIT	00000	00000	0	000	100	000	000	1.00	
.2	01	A	81-249982-00	TT		WIRE16AWGREDTEFLONIN	EA	1.0000	1.000	0		AUDIT	00000	00000	0	000	000	000	000	1.00	
.2	01	A	81-249986-00	TT		WIRE16AWGBLUETEFLONI	EA	1.0000	1.000	0		AUDIT	00000	00000	0	000	000	000	000	1.00	
1	01	C	00-192222-00	*		CATH STEM SUPP ASSY	EA	1.0000	1.000	0		AUDIT	00000	00000	0	000	100	000	000	1.00	
.2	01	C	00-192209-00	*		INNER HEAT SHLD ASSY	EA	1.0000	1.000	0		AUDIT	00000	00000	0	000	100	000	000	1.00	
.2	01	C	00-192210-00	*		HEATER CATH PKG ASSY	EA	1.0000	1.000	0		AUDIT	00000	00000	0	000	100	000	000	1.00	
.2	01	A	07-664006-00	TT		.005X.100 PURE PLAT	EA	1.0000	1.000	0		AUDIT	00000	00000	0	[illegible]	000	000	000	1.00	
.2	01	B	00-166501-00	E	D	LEAD SUPPORT ASSY	EA	1.0000	1.000	0		AUDIT	00000	00000	0	000	000	000	000	1.00	
..3	01	A	00-142138-00	*		LEAD BUSHING STOP	EA	1.0000	1.000	0		06746	00000	00000	0	000	200	000	000	1.00	
..3	01	A	02-451500-60	TT		.062 DIA RD NICKEL B	EA	1.0000	1.000	0			00000	00000	0	000	000	000	000	1.00	
..3	01	A	07-166001-50	TT		.015 DIA 35/65 AUCU	EA	.5000	.500	0		06746	00000	00000	0	000	000	000	000	1.00	
..3	01	A	00-0C1834-00	*	*	LEAD SUPPORT	EA	2.0000	2.000	0		05973	00000	00000	0	000	000	000	000	1.00	
..3	01	A	00-166486-00	C	*	MTLZD BUSHING	EA	1.0000	1.000	0			00000	00000	0	000	000	000	000	1.00	
...4	01	A	00-166487-00	C	*	LEAD BUSHING	EA	1.0000	1.000	0			00000	00000	0	000	000	000	000	1.00	
..3	01	A	00-166789-00	C	A	BRAZING WAFER	EA	2.0000	2.000	0		06746	00000	00000	0	000	000	000	000	1.00	
..3	01	A	00-166790-00	*	A	LEAD WASHER	EA	1.0000	1.000	0			00000	00000	0	000	000	000	000	1.00	
.2	01	C	00-192181-00	*		CATHODE STEM ASSY	EA	1.0000	1.000	0		AUDIT	00000	00000	0	000	100	000	000	1.00	
..3	01	B	00-192182-00	*		STEM SUPPORT A	EA	1.0000	1.000	0		AUDIT	00000	00000	0	000	200	000	000	1.00	
..3	01	B	00-192183-00	*		STEM SUPPORT B	EA	1.0000	1.000	0		AUDIT	00000	00000	0	000	200	000	000	1.00	
..3	01	B	00-192184-00	*		STEM SUPPORT C	EA	1.0000	1.000	0		AUDIT	00000	00000	0	000	200	000	000	1.00	
.2	01	B	00-192185-00	*		FOCUS ELECTRODE ASSY	EA	1.0000	1.000	0		AUDIT	00000	00000	0	000	100	000	000	1.00	
..3	01	B	00-192186-00	*		FOCUS ELECTR SLEEVE	EA	1.0000	1.000	0		AUDIT	00000	00000	0	000	200	000	000	1.00	
..3	01	B	00-192187-00	*		CATH SUPPORT SLEEVE	EA	1.0000	1.000	0		AUDIT	00000	00000	0	000	200	000	000	1.00	
..3	01	B	00-192189-00	*		FOCUS ELECTRODE	EA	1.0000	1.000	0		AUDIT	00000	00000	0	000	200	000	000	1.00	

APPENDIX E

"ELECTRON GUN BREAKDOWN"

by

Dr. Armand Staprans, Varian Associates, Inc.

1985 High-Voltage Workshop

February 26, 1985

Monterey, California

varian

ELECTRON GUN BREAKDOWN

ARMAND STAPRANS

VARIAN ASSOCIATES, INC.

PRESENTED AT THE
1985 HIGH-VOLTAGE WORKSHOP
FEBRUARY 26, 1985
MONTEREY, CALIFORNIA

Electron Gun Breakdown

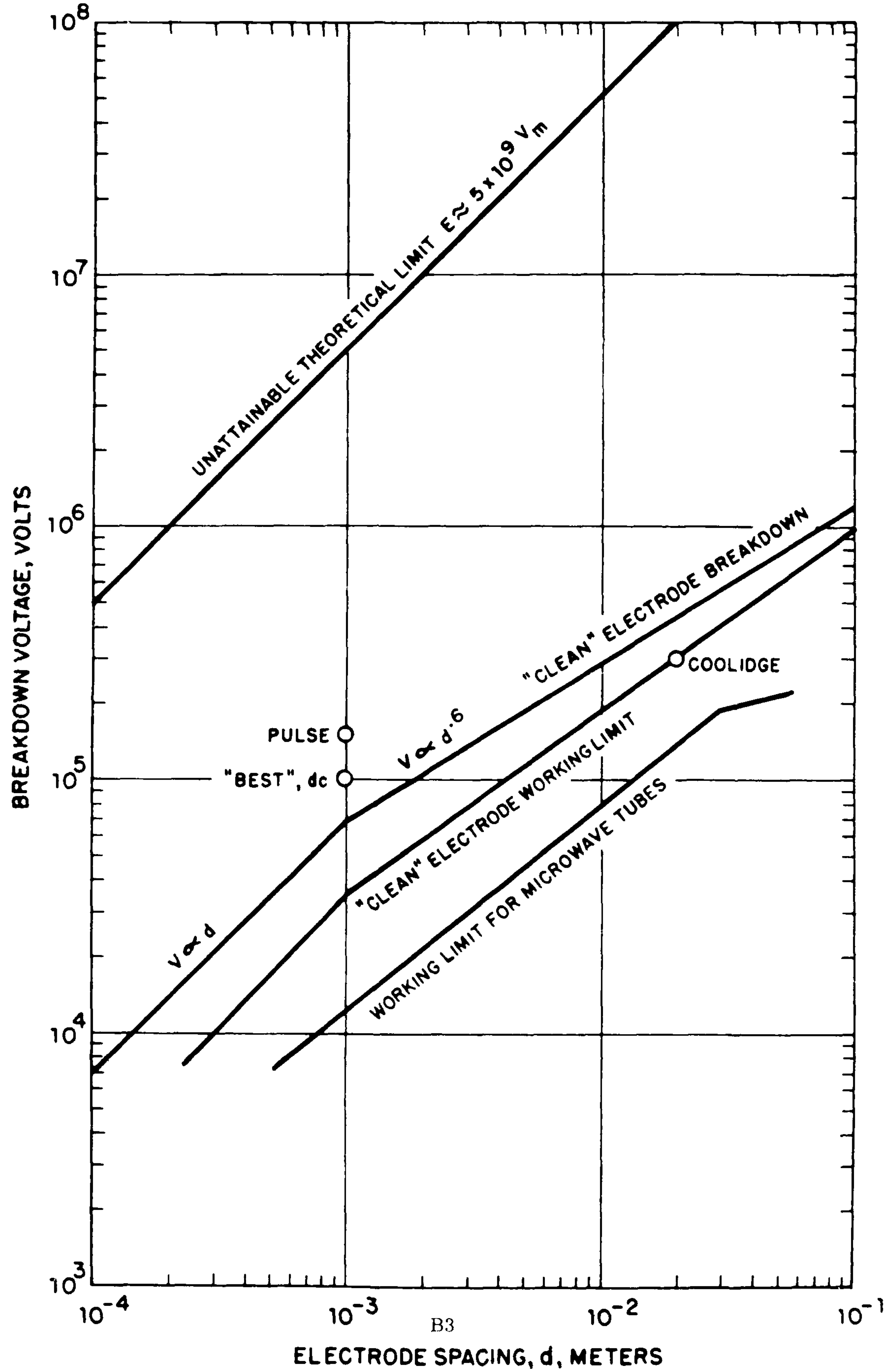
A. Staprans
Varian Associates Inc.
611 Hansen Way
Palo Alto, CA 94303

The electron gun is usually the portion of a microwave tube that is most stressed by high voltage and is frequently subject to breakdown. This is a consequence of design constraints which often require the use of close-spaced vacuum gaps between gun electrodes.

The design criteria for voltage hold-off in guns are reviewed. Largely because of the presence of evaporation from a hot cathode, the acceptable safe voltage between gun electrodes is substantially lower than for a similarly spaced "clean"vacuum gap. Design guidelines for achieving adequate voltage hold-off in guns are discussed, including allowable gradients, electrode spacings, pulse vs dc operation, electrode materials, and insulator configurations.

The tube-power supply interface plays a very important role in minimizing gun breakdown. Arc energy limiting means such as crow-bars and arc current limiting impedances are discussed and design criteria suggested.

VACUUM GAP VOLTAGE BREAKDOWN COMPARISON



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SPECIAL FACTORS IN ELECTRON GUN BREAKDOWN

- PRESENCE OF A HOT CATHODE — BARIUM DEPOSITION ON ELECTRODES
- "LOW" IMPEDANCE POWER SUPPLIES — LARGE AVAILABLE ARC ENERGY
- ELEVATED ELECTRODE TEMPERATURES — ENHANCED FIELD EMISSION
- LARGE ELECTRODE AREA (COMPARED TO SPACING)
- COMPLEX ELECTRODE SHAPES — DIFFERENT FROM SIMPLE GAP THEORIES
- PRESENCE OF MAGNETIC FIELD — AFFECTS CHARGED PARTICLE PATHS
- LIMITED CHOICE OF MATERIALS

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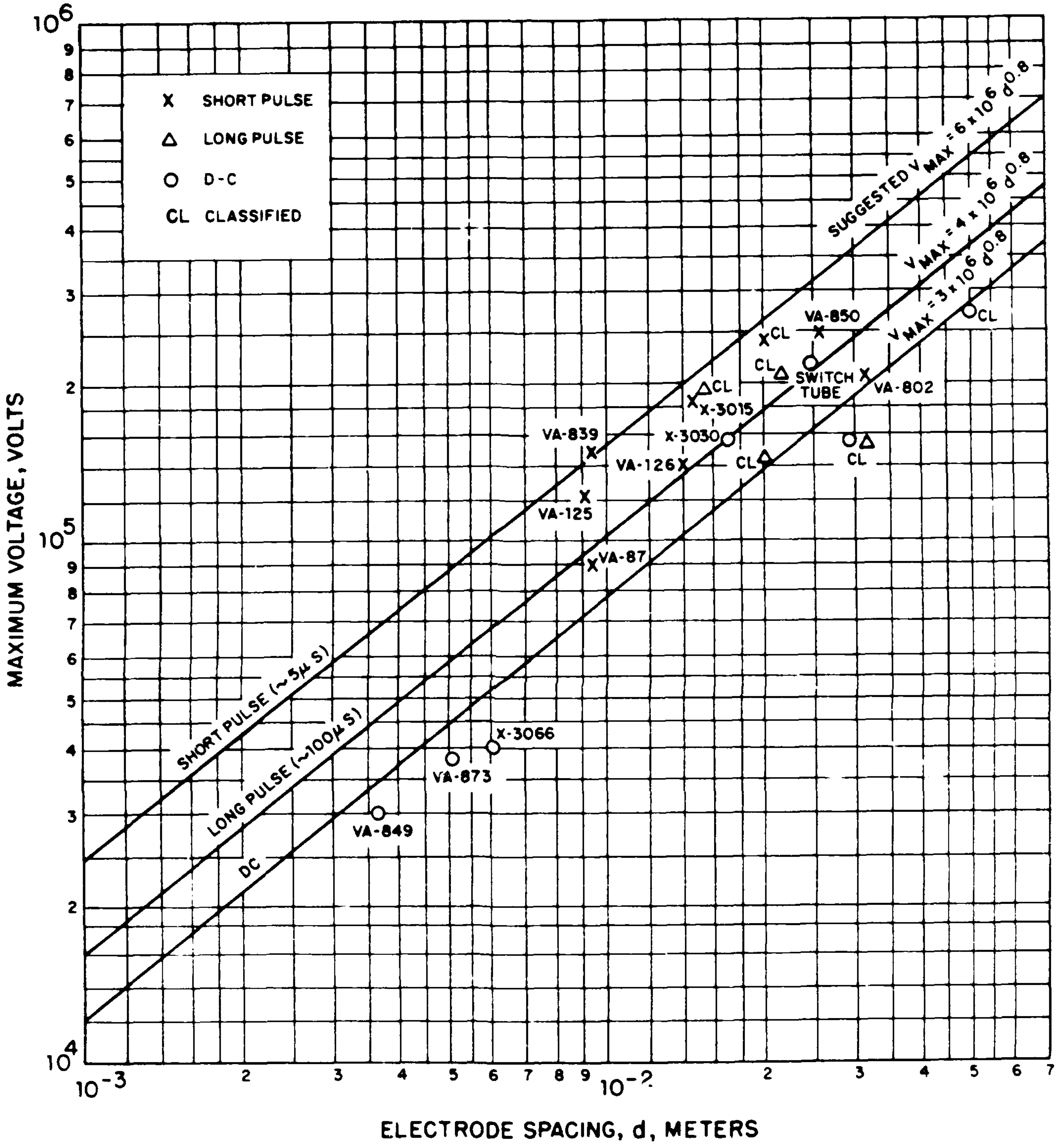
ELECTRODE SPACING RATHER THAN GAP FIELD IS PREFERRED VARIABLE

- FIELD AT ELECTRODE SURFACE IS BUT ONE OF MANY FACTORS AFFECTING BREAKDOWN. ELECTRODE SHAPES AND SIZES ARE ALSO IMPORTANT. MINIMUM SPACING IS A GENERAL PARAMETER.
- FOR WELL DESIGNED GUN FOCUS ELECTRODES, FIELD ENHANCEMENT FACTOR ABOVE V/d IS LOW:

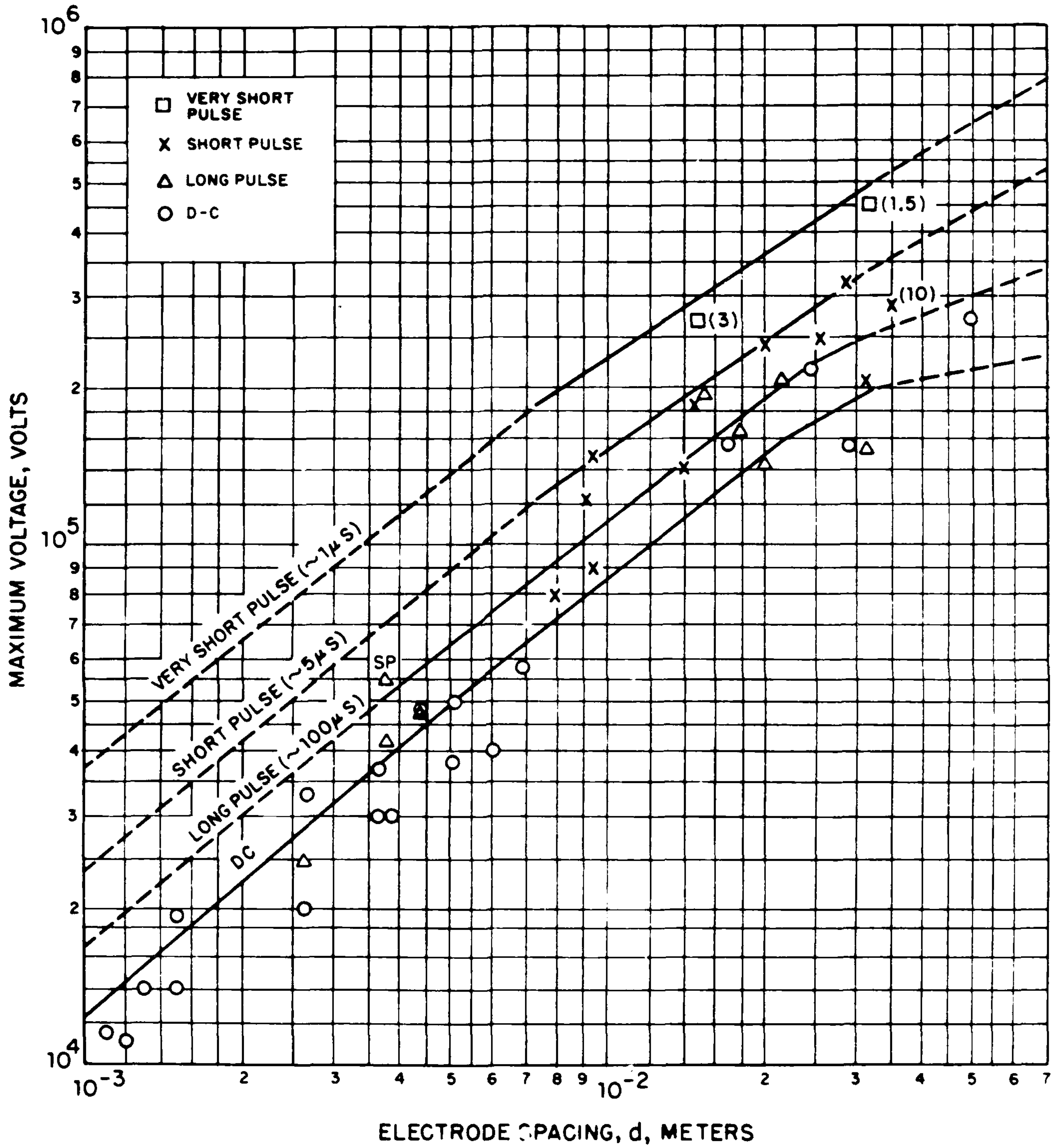
USUAL RANGE	1.3 to 1.7
AVERAGE	1.5

- ELECTRODE SPACING DATA IS MORE AVAILABLE THAN GRADIENTS
- EXISTING DATA YIELDS FAIRLY CONSISTENT RESULTS
- CONVENIENT DESIGN PARAMETER

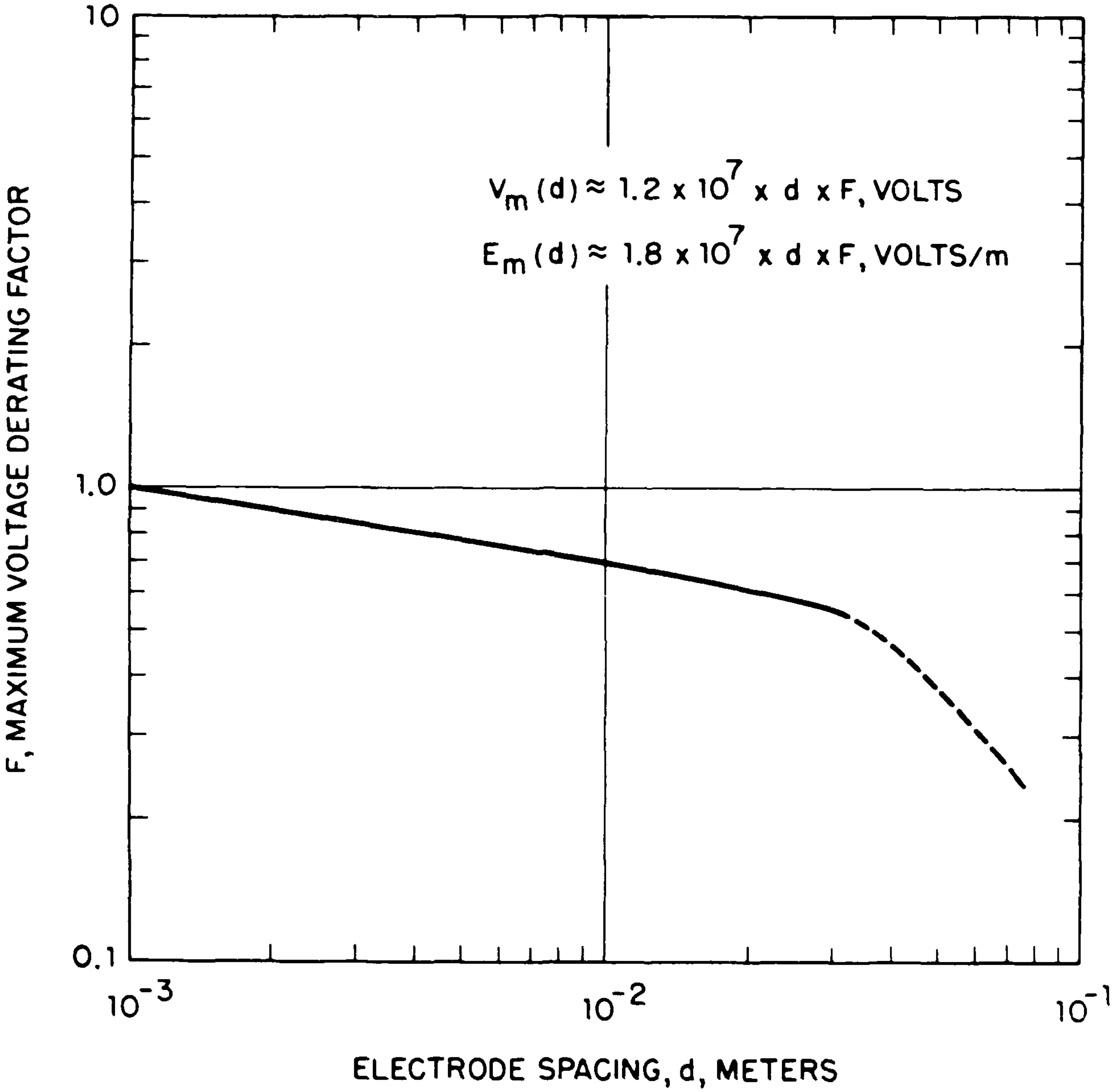
GUIDE TO HV SPACING DESIGN IN ELECTRON GUNS (1966)



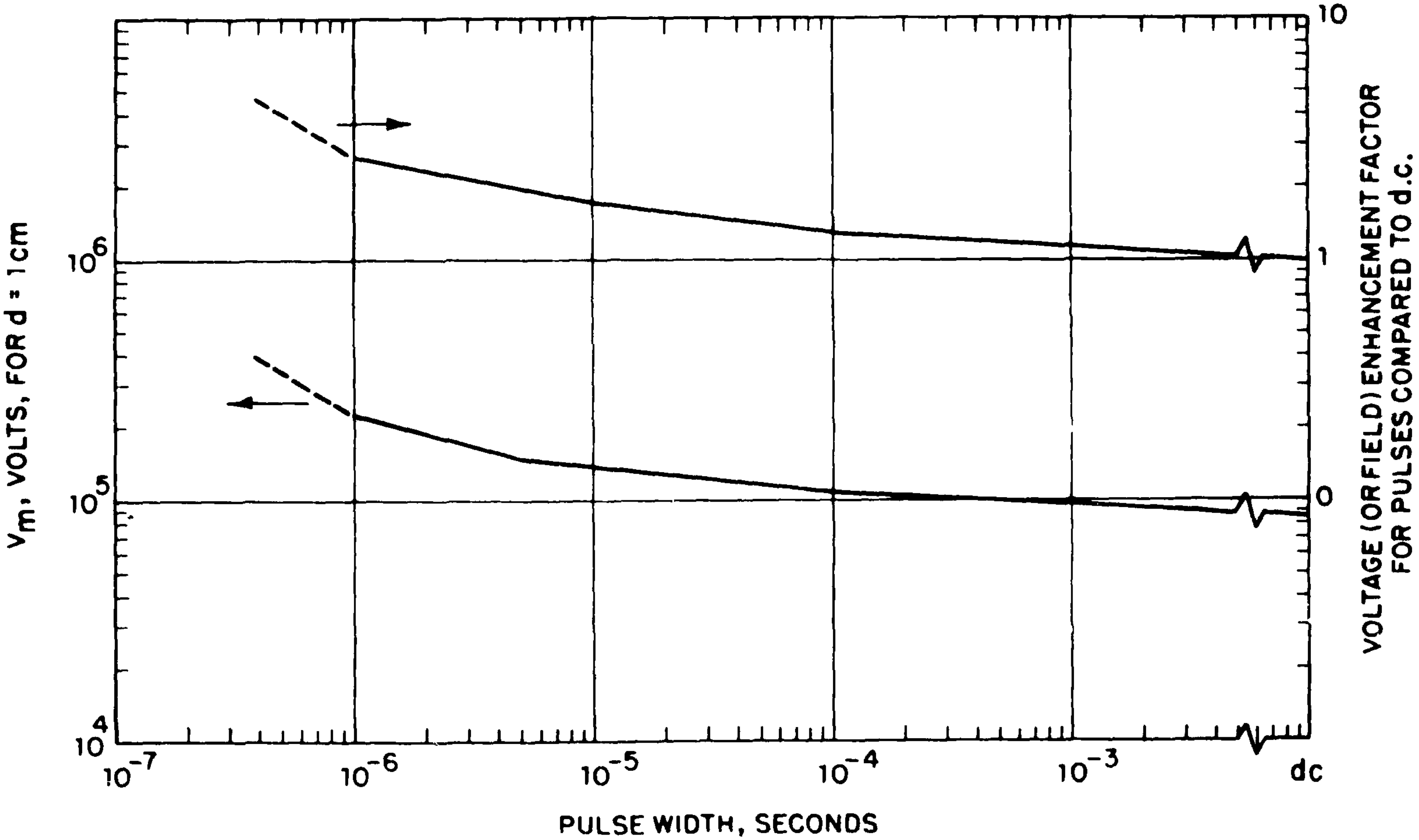
GUIDE TO HV SPACING DESIGN IN ELECTRON GUNS (1985)



MAXIMUM DESIGN VOLTAGE, V_m, OR FIELD, E_m, DERATING FACTOR, F, FOR ELECTRODE SPACINGS ABOVE 1 mm FOR d.c. CONDITIONS



MAXIMUM DESIGN VOLTAGE, V_m, vs. PULSE WIDTH



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SUMMARY OF DESIGN CRITERIA

- **CURVES OF MAXIMUM VOLTAGE vs ELECTRODE SPACING FOR PULSE AND DC**

- **ALTERNATELY, FOR MORE APPROXIMATE ESTIMATES AND PARAMETRIC CALCULATIONS, FOR GAPS UP TO ABOUT 3 cm, THE FOLLOWING APPLIES:**

$$V_{max} \approx K \times 10^6 d^{0.8}, \text{ where}$$

$K \approx 3$ FOR DC
≈ 4 FOR 100 msec PULSES
≈ 6 FOR 5 msec PULSES
≈ 9 FOR 1 msec PULSES

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ELECTRODE MATERIALS AND SURFACES

- FOR NEGATIVE (FOCUS) ELECTRODE, STAINLESS STEEL (SOMETIMES OXIDIZED) IS COMMON USAGE. IRON AND MOLYBDENUM ARE ALTERNATES. COPPER IS STILL USED FOR THE LOWER VOLTAGES.
- COPPER, STAINLESS STEEL AND IRON ARE USUAL ANODE MATERIALS, BUT STAINLESS STEEL IS PREFERABLE.
- MECHANICAL POLISHING AND SUBSEQUENT CLEANING IS PREFERRED, BUT CARE MUST BE TAKEN TO PREVENT SURFACE CONTAMINATION.
- MICROSCOPIC PROPERTIES OF SURFACES ARE IMPORTANT.

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GUN INSULATOR ISSUES

- SURFACE BREAKDOWN CAN OCCUR FROM ELECTRON EMISSION FROM THE TRIPLE JUNCTION AND SECONDARY ELECTRON MULTIPLICATION AND CHARGING, OR FROM SURFACE CONTAMINATION/LEAKAGE.

- DESIGN CRITERIA FOR CERAMIC INSULATORS:
  - LENGTH $\sim$10 X THAT OF EQUIVALENT VACUUM GAP
  - WALL THICKNESS TO WITHSTAND FULL APPLIED VOLTAGE
  - GROOVED OR ROUGHENED VACUUM SIDE SURFACES
  - SHIELDING FROM CATHODE, ARC, AND BEAM HEATING EVAPORANTS
  - CORONA SHIELDS FOR TRIPLE JUNCTIONS
  - FIELD CONCENTRATION, IF ANY, ON NEGATIVE END OF INSULATOR

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ARC CHARACTERISTICS AND PROTECTION CRITERIA

- BUILDUP TIME IS SHORT — TEN(S) OF NANOSECONDS
- SUBSEQUENT METAL VAPOR ARC DROP IS LOW — ABOUT 20 VOLTS
- ELECTRODE AND LEAD/BUSWORK STORED ENERGY IS ALWAYS AVAILABLE TO THE ARC (BUILDUP) — USUALLY LESS THAN 1 JOULE
- SUBSEQUENT ARC DISSIPATION SHOULD BE LIMITED TO A COMPARABLE VALUE, $\sim$ 1 JOULE, BY PROTECTIVE CIRCUITRY
- COMMON TUBE SPECIFICATION REQUIREMENTS OF LARGER ARC ENERGIES, E.G. 40 JOULES, ARE UNREALISTIC AND ONLY FUNCTION BECAUSE ONLY A SMALL FRACTION OF THIS ENERGY IS DISSIPATED IN THE ARC

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RECOMMENDED MEASURES FOR $\sim$1 JOULE DISSIPATION

- KEEP ELECTRODE AND LEAD/BUSWORK CAPACITANCES LOW
- IF POSSIBLE, "ISOLATE" POWER SUPPLY FROM GUN BY PROVIDING A TIME CONSTANT MUCH LARGER THAN ARC BUILDUP TIME
- FOR UP TO ABOUT 20 KV, A 50 TO 100 Ω SERIES RESISTOR, AND ARC CURRENT LIMITATION TO ABOUT 100 A IS ADEQUATE
- FOR VOLTAGES ABOVE ABOUT 40 KV, AN ELECTRONIC CROWBAR IS USUALLY NECESSARY, ITS SPEED DEPENDENT UPON CURRENT-LIMITING CHARACTERISTICS OF THE SUPPLY:

  100 A MAX $\rightarrow$ 0.5 msec CROWBAR

  10,000 A MAX $\rightarrow$ 5 μsec CROWBAR

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SUMMARY

- NO SIGNIFICANT IMPROVEMENTS IN GUN VOLTAGE CAPABILITY IN THE LAST 20 YEARS, BUT:
- SIGNIFICANTLY BETTER UNDERSTANDING OF VACUUM ARCS EXISTS
- DESIGN LIMITS AND TECHNIQUES ARE BETTER UNDERSTOOD
- PROTECTIVE CIRCUITS ARE BETTER UNDERSTOOD AND <u>ACCEPTED</u>

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ACKNOWLEDGEMENT

MOST OF THE ELECTRON GUN DATA USED WAS OBTAINED FROM:

VARIAN MICROWAVE TUBE DIVISION

VARIAN BEVERLY MICROWAVE DIVISION

STANFORD LINEAR ACCELERATOR CENTER (G. KONRAD)

LITTON ELECTRON DEVICES (R. TRUE)